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Editorial

More Magnetic Fallacies

UNDER the title of "The Electromagnetic Mental Picture" a letter was published in *Nature* of February 28th in which H. Stafford Hatfield discusses the presentation to students of "engineering electricity" with special reference to the teaching of radio telegraphy. He remarks that recent textbooks reflect a certain uneasiness, some teachers advocating classical field theory alone while others introduce the electron theory and link it up with the field theory at every stage. In an earlier letter to *Nature* (August 16th, 1941) he had put forward a method of explaining the induction of e.m.f. in terms of the moving electrons without reference to any magnetic field. He advocates basing the consideration of capacitance, inductance and transmission upon the "particle picture," and says that "historical piety should not lead us to burden the beginner's mind with the difficulties and artificialities of the magnetic field picture." While admitting the usefulness of the field picture, he says that "the literature from the time of Faraday to the present day affords numerous examples of futile experiments and discussions based upon a too literal interpretation of it." This is perfectly true, and we need hardly remind our readers that many a sermon has been preached on the same text.* We doubt, however, whether the average student or engineer is troubled by the pseudo-philosophic and usually meaningless questionings which lead to the carrying out of these futile experiments. We should hesitate to throw the magnetic field overboard after a century of useful service, simply because some people, who mistakenly endow the lines of force with concrete reality, and regard them as bristles or fibres which can be individually earmarked and followed about, persist in asking meaningless questions about their movement. The writer of the letter then gives two cases in which he says that "the field picture as usually stated seems to be inadequate"; he is careful not to say that it is inadequate, but only that it seems to be. When a person tells you that the room seems to go round, you may be sure that there is something wrong—but not necessarily with the room. Let us look into these two cases. "If a horseshoe magnet be rotated when placed so as to send flux through a few turns only of a short-circuited toroid, the field theory seems to call for an alternating current in the toroid, with no reactive torque on the magnet." On the contrary, the field theory definitely rules out the possibility of such a thing or even of placing a magnet so as to send flux through a few turns only. The line integral of H around any closed path in the field of the magnet is zero. This applies to any of the dotted circles in Fig. 1, hence $\Sigma\phi\delta l = 0$ where ϕ is the normal flux in the toroid at any cross-section. If there is a constant number of turns per cm. it is immaterial whether ϕ be multiplied by the length δl or by the number of turns $\frac{T}{l}\delta l$ in this element of length. Hence the total number of linkages is zero whatever the position of the magnet and no e.m.f. can be induced in the toroid by its rotation. To make this statement absolutely correct the toroid should be wound with two layers of wire in series, in one of which the current follows a right-handed screw and in the other a left-handed screw around the toroid, otherwise the whole winding would act as a single short-circuited turn through which flux would pass normal to the paper in Fig. 1 when the magnet was turned. It is now evident that a magnet cannot be placed " so as to send flux through a few turns only," as the writer of the letter premised—we suspect with his tongue in his cheek.

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* "A Perennial Chimera," G. W. O. Howe, *Electrician*, 1934, pp. 329, 399. "A Persistent Fallacy," G. W. O. Howe, *Electrician*, 1936, pp. 191, 493. "Magnets and Fields of Force," G. W. O. Howe, *Electrician*, 1936, p. 625.

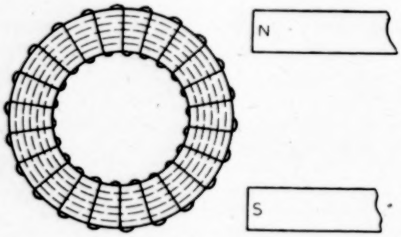

Fig. 1.

Torque

Turning now to the other case, we are told that " if a toroid solenoid is placed with its plane at right-angles to that of a horseshoe magnet and with a few of its turns in the pole gap of the magnet, the field picture seems to call for a torque on the toroid, but none on the magnet." Although he does not say so, the writer assumes that the toroid is carrying a current.

From what we have seen in the first case there can obviously be no torque since there is no linkage, whatever the relative position of the toroid and magnet. This case is, however, much more interesting and may cause some readers a little trouble. Surely, they will say, the conductors carrying current in the horizontal magnetic field of the magnet will experience a vertical force, upwards on one side and downwards on the other, and thus exert a torque tending to tilt the toroid. This is quite true, but yet the toroid does not tilt, and the magnet experiences no torque. The field of the magnet outside the toroid cannot be affected since the toroid has no external field, hence no torque can be exerted on the magnet by the current. The field of the magnet enters the toroid symmetrically, but inside the toroid it is compounded with the solenoid field, which is therefore distorted as indicated in Fig. 2. The force on the conductors is exactly that calculated from the field of the magnet and the current in the conductor, and the direction is that given by the left-hand rule, but the field picture shows that the force is transmitted internally from one side of the toroid to the other *via* the skewed magnetic field. The toroid shows no more tendency to rotate than does a person who pulls steadily at his own braces.

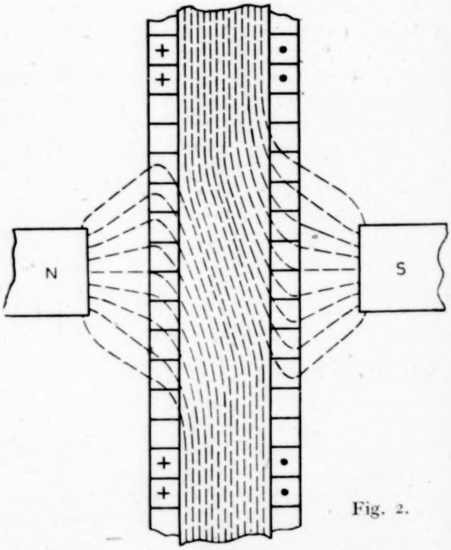

Fig. 2.

It requires no historical piety to admire the beauty of this magnetic field picture.

There is another point mentioned in the letter. The writer says that he asked more than a dozen highly skilled physicists and radio research men whether the inductance of a straight wire is greater or less than that of the same wire bent into a circle, and that without exception they answered wrongly. It is difficult to see how the magnetic field picture can be blamed for this lamentable state of affairs. It is probable that the highly skilled persons had been brought up on an electron diet and were suffering from a magnetic field deficiency. It would be interesting to know what the questioner himself understands by the inductance of a straight piece of wire. This subject was very much discussed in the pages of the *Elektrotechnische Zeitschrift* about thirty-five years ago, when a proposed set of definitions included one of the inductance of a straight piece of wire. It was pointed out* that Neumann's approximate formula $L = 2l\left(\log_e \frac{2l}{r} - 1 + \frac{\mu}{4}\right)$, where μ is the permeability of the wire, is based on an arbitrary and unjustifiable assumption, and that the inductance is really infinite. The whole thing is fictitious because it assumes a straight piece of wire carrying a steady current without any other conductors in the neighbourhood. If the wire concerned is AB in Fig. 3 and it be assumed to carry unit current—and no questions asked as to how the current gets in or out of the wire—the strength of the field at every point can be calculated by the ordinary Biot-Savart formula, and on integrating throughout space, the total flux is found to be infinity. If, however, all the flux outside the two dotted planes in Fig. 3 be excluded from the integration, which, by the way, means neglecting an infinite amount of flux, due entirely to the current in the piece of wire, then the above formula is obtained. This may, perhaps, be useful, but it is hardly correct to call it the self-inductance of the piece of wire. Notwithstanding the above-mentioned discussion, this formula was given in the *Bulletin of the Bureau of Standards*, Vol. 8, No. 1, 1916, p. 150, without any comment ; an analogous formula $M = 2l\left[\log \frac{2l}{d} - 1 + \frac{d}{l}\right]$ was given for the mutual inductance between two wires situated as shown in Fig. 3 at a distance d. The definition given is interesting, viz., " the mutual inductance of two parallel wires of length l, radius r and distance apart d is the number of lines of force due to unit current in one, which cut the other when the current disappears." Not, be it noted, when the current is established, since that would raise some awkward questions, for the whole of space is gradually occupied by circular lines of force which presumably originate at the wire AB, and not only expand radially but move laterally. How many of the infinite number of lines of force which ultimately lie outside the pale cut the wire CD in their movement ? Instead of attempting to answer this meaningless question, which would necessitate materialising and ear-marking the lines so as to be able to trace their movements, the definition lets the current die away and assumes arbitrarily that the lines of force all collapse radially ; the wire CD is then only cut by those between the two dotted planes, and these are finite in number and given by the above formula. Why, when the current decreases, the lines do not exactly retrace the movement they made when it increased, it is difficult to see. It should be carefully noted, however, that all this—dare we say nonsense ?—is due not to any magnetic field picture, but to the attempt to define something which is physically impossible and inconceivable.

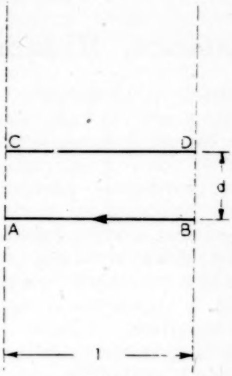

Fig. 3.

Self-Inductance of a Solenoid

What do we mean when we speak of the self-inductance of a solenoid ? If an isolated straight piece of wire has an infinite inductance, the same must be true, only more so—of a solenoid between the same two terminal points. Here again we cannot assume a steady current in the coil apart from the remainder of the circuit without doing violence to any intelligent conception of nature. By the inductance of a solenoid we must understand the increase in the inductance of a circuit when the solenoid replaces a straight piece of wire between the same terminals.

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* Guttsmann, 1905, pp. 764, 851, 936 ; Emde, 1905, pp. 851, 935 ; also 1907, p. 185 ; Sumec, 1906, p. 1175 ; Wagner, 1907, pp. 673, 1002, 1132.

We see, therefore, that the problem propounded to the highly skilled physicists and radio research men was not nearly so simple as it sounded, but involved the comparison of a finite real quantity with an infinite imaginary one. G. W. O. H.

Pulsatance, Rotatance or Velocitance?

IF one, why not the others ? " Pulsatance " was proposed many years ago and has been used to some extent as a name for the angular velocity of the vector representing an alternating voltage or current, but surely it is a very inappropriate name. The word " pulse " conveys a very definite idea. The dictionary gives " *pulsate,* to beat, as the heart or a vein ; to throb " ; also " *pulsation,* a beating or throbbing ; any measured beat ; a vibration." Now, if anyone could see, feel, or hear the variations of an alternating current or voltage, they would have no doubt about the suitability of the word " pulsation " to describe the phenomenon, and if asked to count the pulse, their only doubt would be whether a complete cycle should be counted as one or as two pulses. If superposed upon a steady current, even this doubt would be unlikely to arise. Surely, then, " pulsatance," if used at all, should signify what is universally called the frequency.

The alternating current or voltage can be represented by the projection on the vertical of a rotating line usually called—to the annoyance of mathematical purists—a vector. This line must rotate f times per second, and therefore its angular velocity ω is $2\pi f$ radians per second. There is nothing whatever pulsating about this angular rotation ; there are 2π radians in each revolution, but certainly not 2π pulses. Why, then, refer to this steady angular velocity as the pulsation or pulsatance ? Someone may suggest that the pulsatance is the number of pulses in 2π seconds, just as the frequency is the number in one second, but this is not the sense in which the word is used, for it is always given as so many radians per second. Many people avoid its use by referring to a frequency of $1{,}000/2\pi$ cycles per second rather than a pulsatance of 1,000 radians per second. Surely either " rotatance " or " velocitance," strange though they may sound, are preferable to " pulsatance " as a name for, or associated with, a rate of steady rotation. One would soon become accustomed to speaking of an alternating current with a rotatance of 1,000 radians per second. It is certainly more suggestive of what it represents than a pulsatance of 1,000 radians per second. The difficulty is that while there is nothing pulsational about the rotating vector, there is also nothing rotational about the alternating current, and consequently any term used to link them is almost bound to consort badly with one or the other. What is required is really an abbreviation of vector-angular-velocity, but we cannot think of anything better than " rotatance," although " radiance " struck us as a bright idea. It would be interesting to know the views of our readers on the matter.

G. W. O. H.

Meeting a Need

READERS who in the past have been accustomed to consulting foreign technical journals at libraries, or subscribing to them direct, have been unable to do so as a result of the war. Our Abstracts and References section is often the only remaining guide to them as to what is being published abroad. As a result of requests, and in order to help remedy this state of affairs, it is proposed to publish translations of foreign papers of special interest and occasionally to reprint from journals printed in English where the journals are not generally available in this country.

This arrangement is being introduced with the publication in this issue of an article by Dr. A. L. Green entitled " Superheterodyne Tracking Charts," which appeared in No. 3, Vol. 5, of the *A.W.A. Technical Review.*

Superheterodyne Tracking Charts—I *

By A. L. Green, Ph.D.

ABSTRACT.—It is well known that the formulae customarily used for the calculation of padding and trimming condensers in the oscillator section of a superheterodyne receiver are cumbersome and susceptible to arithmetical error. This report introduces formulae, suitable for slide-rule computations, that arise out of simple modifications of the early two-point tracking analysis. The modifications include a certain correction factor (k), for which numerical values are given in the form of charts.

1. Historical Summary.

IT was recognised at an early stage in the development of the commercial superheterodyne receiver, that ease of operation demands the inclusion of a uni-control tuning mechanism. As is now well known, the design problems associated with this desirable feature are incurred in the requirement that the oscillator tuning must track with the signal-circuit tuning. More precisely, it is necessary that the difference between the frequencies of the signal and oscillator circuits be a constant quantity, equal to the intermediate frequency of the receiver, independently of the setting of the tuning dial.

In an early experimental receiver, Chinn (1931)† secured effective tracking of the signal and oscillator circuits by shunting an adjustable trimming condenser across the signal circuit, thus reducing the frequency ratio of this circuit in comparison with the oscillator. In this receiver the oscillator frequency was always lower than that of the signal circuit. At about the same time, Andrewes (1931) described the use of both a parallel trimming condenser and a series padding condenser in the oscillator circuit, for the purpose of reducing the frequency ratio of the oscillator circuit. In the same year, Haynes and Cocking (1931) claimed to have produced the first solution to the problem of securing correct tracking in a receiver that included both medium-wave and long-wave ranges. Briefly, the method provided a series padder in the oscillator circuit, the same condenser being used on both wave ranges, and independent parallel oscillator trimmers for the two bands.

The generally accepted solution to the superheterodyne tracking problem was given by Sowerby, in 1932, in an article which described clearly the idea of three-point tracking and the fact that the values of both the oscillator padder and trimmer are uniquely determined by this criterion. Briefly, it was shown that the earlier designs were subject to serious tracking errors towards the centre of a band in which correct alignment had been secured at the two extreme tuning points. In Sowerby's three-point tracking, correct alignment was also achieved at a third tuning point, which could conveniently be specified as the arithmetic-mean frequency of the band. This article has remained the authority on the superheterodyne problem until the present day, although somewhat similar results have been obtained by other authors, including Landon and Sveen (1932), Kautter (1935), Roder (1935), Singer (1936) and Couppez (1936). A more ambitious four-point tracking scheme has been described by Lange (1937), but in this case the oscillator circuit includes a two-section ganged tuning condenser.

A useful result of considerable practical importance was derived in 1937 by Cocking, who presented the case for padding condensers of fixed values, thus eliminating the earlier adjustable padder. Cocking demonstrated that an easily obtained manufacturing tolerance in padder capacity was quite sufficient for satisfactory three-point tracking. In the same year, however, Sklar had described an automatically adjusted padding condenser to give an approach to perfect tracking at all tuning points in the band, in place of the customary three-point tracking. This method requires the use of a small variable condenser, shunted across a fixed padder and ganged with the main tuning condenser.

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* Reprinted from *A.W.A. Technical Review*, 1941, Vol. 5, No. 3, by arrangement with Amalgamated Wireless (Australasia) Ltd.

† See chronological bibliography at end of article.

More recent articles have discussed the problem of three-point tracking from the point of view of using outer tracking points which differ somewhat from the extreme limits of the band. It has been shown by Cocking (1938), in "Electron Art" (1939), and by Wald (1940), that this refinement reduces the maximum tracking error.

Although the present paper is concerned with the problem of three-point tracking, it is important to remember that an alternative scheme is available for use in receivers that include only one wave-band. This method requires the use of a specially shaped oscillator section of the ganged tuning condenser, and of prior knowledge of the stray minimum capacitances in the signal and oscillator circuits. Mathematical treatments have been given by Schwartzmann and Burnell (1934), and by Schad (1935), and it was pointed out that it is still necessary to add padding condensers, and to rely on Sowerby's analysis, if the tuning range is extended to more than the one band for which the tuning condenser has been designed.

2. Two-point Tracking.

In superheterodyne design problems it is frequently necessary to estimate the values of the oscillator padding and trimming condensers, in order to obtain an approximate value of the oscillator inductance. Unfortunately, however, it is by no means a simple matter to compute values of these two components from the Sowerby formulae. In general, it appears to be easier to use the elementary two-point tracking formulae, for the purpose of estimating very approximate values of the components in the oscillator circuit, and to rely on a more precise evaluation by experiment at a later stage. It is known, empirically, that this procedure gives satisfactory results for a short-wave band, i.e., one in which the signal frequency is far removed from the intermediate frequency of the receiver. On the other hand it is also a matter of experience that the two-point tracking analysis is inadequate for medium-frequency and low-frequency bands, i.e. bands in which the mean signal frequency is comparable with or lower than the intermediate frequency.

The two-point tracking formulae may briefly be stated as follows :—

ω_1 = low-frequency tracking point of the signal circuit,

ω_2 = high-frequency tracking point of the signal circuit,

ω_i = intermediate frequency,

$\alpha = \omega_2/\omega_1$ = signal frequency ratio,

$\beta = \dfrac{\omega_2 + \omega_i}{\omega_1 + \omega_i}$ = oscillator - frequency ratio,

L, L_0 = signal and oscillator inductances,

C, C_0 = signal and oscillator trimming capacitances,

C_p = padding capacitance,

C_g = added capacitance of each section of the ganged tuning condensers.

The circuits assumed to be used are indicated in Fig. 1, and it is particularly to be noted that the trimming capacitances C and C_0 include, not only the customary and fixed portions of the trimmers, but also allowances for the minimum capacitance of the ganged tuning condenser, input and output valve capacitances and all strays. In the formulae all frequencies are in angular measure.

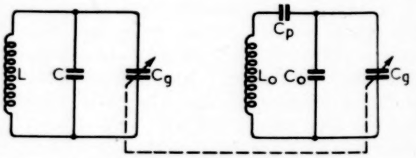

Fig. 1.—*Skeleton circuits on which the analysis is based.*

The four equations for two-point tracking are obviously :—

$$L\,(C_g + C)\,\omega_1^2 = 1 \qquad \ldots \qquad \ldots \qquad (1)$$

$$LC\omega_2^2 = 1 \qquad \ldots \qquad \ldots \qquad (2)$$

$$L_0\,(\omega_1 + \omega_i)^2 = \frac{1}{C_p} + \frac{1}{C_g + C_0} \qquad \ldots \qquad (3)$$

$$L_0\,(\omega_2 + \omega_i)^2 = \frac{1}{C_p} + \frac{1}{C_0} \qquad \ldots \qquad (4)$$

The quotient of expressions (1) and (2) immediately gives the value of the signal-circuit trimmer as

$$C = \frac{C_g}{\alpha^2 - 1} \qquad \ldots \qquad \ldots \qquad \ldots \qquad (5)$$

and the signal-circuit inductance is then readily derived from tables of LC products, for example Hesse (1938).

It is clearly impossible to solve equations (3) and (4) for unique values of L_0, C_0, and C_p unless a value is first assigned arbitrarily to one of the three variables. In practice it is usual to make the assumption that

$$C_0 \simeq C \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

and it is then easy to show, with the help of expression (5) above, that the value of the padder in two-point tracking is

$$C_{p2} = \frac{\beta^2 - 1}{\alpha^2 - \beta^2} \cdot (C_g + C) \quad \ldots \quad \ldots \quad (7)$$

With C_p and C_0 known, it is again a simple matter to calculate the corresponding inductance.

In general, therefore, expressions (5), (6) and (7) have customarily been used in the calculation of approximate values of circuit constants in superheterodyne tracking problems, in spite of their known inaccuracy.

3. Three-point Tracking.

In order to reduce tracking errors towards the mid-point of a band, Sowerby has shown that the receiver may be aligned at a third tracking point which, for convenience, may be the arithmetic-mean frequency of the band to be covered. We therefore define

$\omega_3 = \dfrac{\omega_1 + \omega_2}{2}$ arithmetic-mean signal tracking frequency,

$C_3 =$ added capacitance of each section of the ganged tuning condenser at the tracking frequency,

$\omega_3 + \omega_i =$ corresponding oscillator tracking frequency.

Corresponding with the four LC equations (1), (2), (3) and (4) for two-point tracking, there are two additional expressions for the third tracking point as under :—

$$L(C_3 + C)\omega_3^2 = 1 \quad \ldots \quad \ldots \quad (8)$$

$$L_0(\omega_3 + \omega_i)^2 = \frac{1}{C_p} + \frac{1}{C_3 + C_0} \quad \ldots \quad (9)$$

and it is also convenient to introduce a further frequency ratio (δ), which defines the proximity of the band to the intermediate frequency of the receiver, i.e.,

$$\delta = \frac{\omega_i}{\omega_3} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

Trimmers.—The method of attack is to follow the two-point tracking solution by first solving equations (1) and (2) to obtain

$$C = \frac{C_g}{\alpha^2 - 1} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

as before. Next, eliminate L_0 and C_p between equations (3), (4) and (9), leaving an expression containing only the two unknown quantities C_3 and C_0. The quantity C_3 is readily found in terms of C from equations (2) and (8), by eliminating L, and then it is only necessary to remove C_3 from the two derived expressions in order to find C_0 in terms of the known C. This procedure, with the help of (5), leads to the following solution :—

$$C_0 = \frac{C_g}{(1 - k)\,\alpha^2 - 1} \quad \ldots \quad \ldots \quad (11a)$$

in which the new symbol (k) is, in effect, a correction factor which differentiates between two-point and three-point tracking. The correction factor has the form,

$$k = \frac{4\delta\,(\alpha^2 - 1)}{(1 + 3\alpha)\,.\,\{3 + \alpha + 2\delta\,(1 + \alpha)\}} \quad (12)$$

from which it is immediately apparent that the amount of correction is negligible for short-wave bands in which δ is obviously a small quantity. For such bands expression (11) reduces very simply to

$$C_0 \rightarrow \frac{C_g}{\alpha^2 - 1} \equiv C \quad \ldots \quad \ldots \quad (11b)$$

which is, of course, the customary assumption, (6), made in the two-point tracking analysis.

Padder.—As to the three-point padder value, it is only necessary to eliminate L_0 between equations (3) and (4), thus relating C_p to C_0, C_g, and β. The solution for C_p is then, with the help of expressions (5) and (11a),

$$C_p = \frac{(\beta^2 - 1)\,(C_g + C_0)}{(1 - k)\,\alpha^2 - \beta^2} \quad \ldots \quad \ldots \quad (13)$$

which demonstrates a remarkable similarity with the previously derived two-point padder value,

$$C_{p2} = \frac{(\beta^2 - 1)\,(C_g + C)}{\alpha^2 - \beta^2} \quad \ldots \quad \ldots \quad (7)$$

Corresponding exactly with the previous discussion on C_0 in short-wave bands, C_p obviously approaches closely to the two-point padder value when the correction factor becomes small, that is to say when δ is a small quantity. On the other hand, for long-wave bands in which δ is actually greater than unity, k becomes a large fraction and it is no longer permissible to use the two-point formulae without the correction factor.

The Two-point-Tracking Assumption.—In the preceding section it was pointed out that the two-point LC equations are insoluble, unless an arbitrary value is assigned to one of the variables. At first sight it would appear to be a safe assumption that

$$C_0 \simeq C \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

that is to say, safe from the point of view of computing a value of the padding condenser that is close to the desired three-point value. Experience shows, however, that this is by no means the case, and it is therefore to be inferred that the assumption expressed in (6) is untenable. The degree of inequality between C and C_0 is readily seen in the comparison of expressions (5) and (11a), whose combination gives

$$\frac{C}{C_0} = 1 - \frac{k \cdot \alpha^2}{\alpha^2 - 1}. \qquad \ldots \quad \ldots \quad (14)$$

It is interesting to notice that the trimmer ratio is independent of the size of the variable tuning capacitance and also that, on account of the presence of the correction factor k, the trimmer ratio obviously tends to unity as the mean frequency of the band is increased.

The ratio of the signal and oscillator trimmers is a quantity of some practical importance in a multi-band receiver, because it may be desired to use a common oscillator trimmer for a plurality of bands, and thereby to reduce the number of components in the tuning unit. In such cases, the maintenance of a constant signal-frequency ratio for all bands immediately equalises the capacitances of the signal-circuit trimmers, and the possibility of extending the principle to the oscillator circuits may then be gauged from expression (14) above. Numerical values of the trimmer ratio are illustrated in Figs. 5, 6 and 7, with respect to the parameter δ.

Arbitrary Tracking Points.—The refinement, described by Cocking (1938), that consists in using arbitrarily chosen alignment frequencies, rather than the outer limits of the band, may readily be introduced into the foregoing formulae. A practical modification may be achieved by continuing to use the symbols ω_1 and ω_2 to denote the outer tracking points, and by introducing the symbols ω'_1 and ω'_2, respectively, for the extreme low-frequency and high-frequency limits of the band to be covered. Correspondingly we define

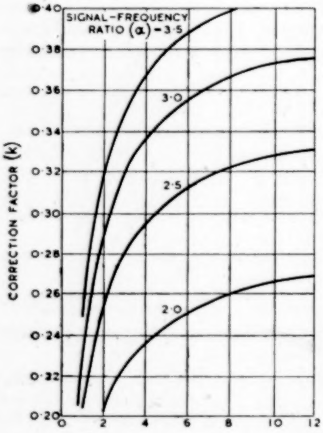

Fig. 2. *Correction-factor chart for low-frequency bands.*

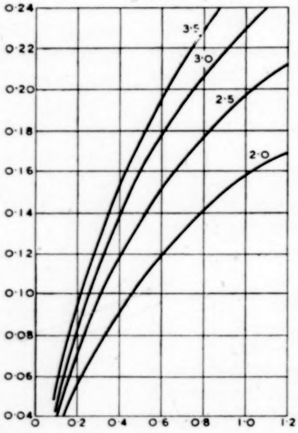

Fig. 3. *Correction-factor chart for medium-frequency bands.*

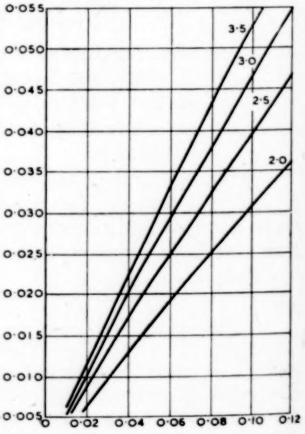

Fig. 4. *Correction-factor chart for high-frequency bands.*

$\alpha' = \dfrac{\omega'_2}{\omega'_1}$ = signal-frequency ratio for the whole band,

C'_g = added capacitance of each section of the ganged tuning condensers, required to tune the signal circuit between ω'_1 and ω'_2.

C', C'_0 = signal and oscillator trimming capacitances, corresponding with the frequencies ω'_2 and $\omega'_2 + \omega_i$.

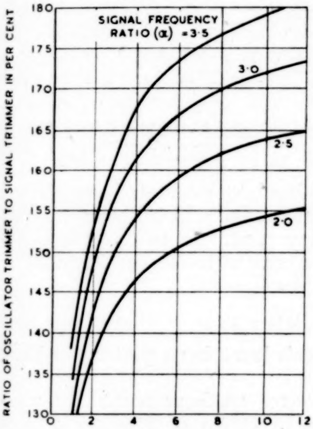

Fig. 5. *Trimmer-ratio chart for low-frequency bands.*

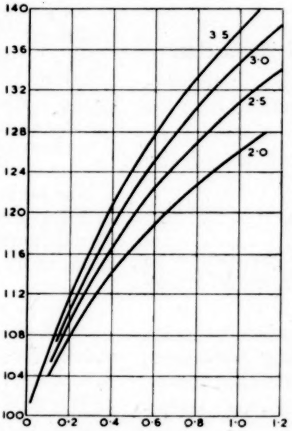

Fig. 6. *Trimmer-ratio chart for medium-frequency bands.*

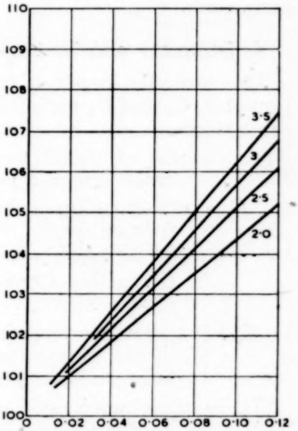

Fig. 7. *Trimmer-ratio chart for high-frequency bands.*

It is to be noted that the quantities C and C_0 still represent the minimum capacitance in each circuit at the high-frequency tracking point, so that each of these symbols now contains a component that is a portion of the variable tuning capacitance.

Usually the value of C'_g is known, since it is the total variation in capacitance of the tuning condenser. On the other hand, if the tracking points are defined in terms of the tracking frequencies ω_1 and ω_2, and not in terms of the corresponding capacitance values of the tuning condenser, it is then necessary to calculate the appropriate value of C_g for use in the formulae. For this purpose we have, for the signal circuit,

$$L(C'_g + C')\omega'^2_1 = 1 \quad \ldots \quad \ldots \quad (15)$$

$$L(C_g + C)\omega_1^2 = 1 \quad \ldots \quad \ldots \quad (1)$$

$$LC\omega_2^2 = 1 \quad \ldots \quad \ldots \quad (2)$$

$$LC'\omega'^2_2 = 1 \quad \ldots \quad \ldots \quad (16)$$

in which $\omega'_2 > \omega_2$
and $\omega'_1 < \omega_1$.

The value of the trimming capacitance for the full band is readily derived from (15) and (16), and is

$$C' = \frac{C'_g}{\alpha'^2 - 1} \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

In order to evaluate C_g, we have, from (2) and (16), that

$$\frac{C}{C'} = \left(\frac{\omega'_2}{\omega_2}\right)^2 \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

and, from (1) and (2), that

$$C = \frac{C_g}{\alpha^2 - 1} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

The combination of (5), (17) and (18) then immediately gives the desired relation between C_g and C'_g, that is to say

$$\frac{C_g}{C'_g} = \left(\frac{\omega'_2}{\omega_2}\right)^2 \cdot \left(\frac{\alpha^2 - 1}{\alpha'^2 - 1}\right) \quad \ldots \quad \ldots \quad (19)$$

Having made the preliminary calculation of C_g, knowing C'_g and the relevant frequencies, it is then possible to proceed with the computation of the remainder of the component values exactly as specified in preceding sections. In brief, Cocking's refinement is introduced by defining a new value of C_g that corresponds, not with the extreme frequency coverage of the band, but with the coverage between the specified tracking frequencies.

Finally it is to be noted that the difference between the calculated values of C and C' obviously represents the variation in tuning capacitance between the high-frequency limit of the band and the high-frequency tracking point. This quantity is readily derived from (5) and (17), after C_g has been computed, and is then available when it is desired to convert the calculated value of C_0 into the more useful C'_0.

4. Summary and Numerical Examples.

The formulae required for the computation of C, C_0 and C_p are summarised here for convenience :—

α = ratio of signal frequencies of the outer tracking points,
β = corresponding ratio of oscillator frequencies,
δ = ratio of intermediate frequency to the arithmetic-mean signal-tracking-frequency,
C_g = capacitance variation of each section of the ganged tuning condenser, between the outer tracking points,
C_p = capacitance of oscillator series-padding-condenser,
C, C_0 = capacitance of signal and oscillator trimmers at the high-frequency tracking point ; the symbols include the customary fixed and variable portions of the trimmers, the minimum capacitance of the tuning condenser, all stray shunt capacitances, and, in the case of arbitrarily chosen tracking points, allowances for the added capacitance of the variable tuning condenser at the high-frequency tracking point,
k = three-point-tracking correction factor,
C'_g = total capacitance variation of each section of the ganged tuning condenser, when this quantity differs from C_g above,
C', C'_0 = capacitance of signal and oscillator trimmers at the high-frequency limit of the band, when this frequency differs from the high-frequency tracking point, and
α' = ratio of signal frequencies of the extreme limits of the band, when these frequencies differ from the outer tracking frequencies.
ω_2, ω'_2 = respectively the high-frequency tracking point and the high-frequency limit of the band.

$$C = \frac{C_g}{\alpha^2 - 1} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

$$C_0 = \frac{C_g}{(1-k)\alpha^2 - 1} \quad \ldots \quad \ldots \quad (11a)$$

$$C_p = \frac{(\beta^2 - 1)(C_g + C_0)}{(1-k)\alpha^2 - \beta^2} \quad \ldots \quad (13)$$

where

$$k = \frac{4\delta(\alpha^2 - 1)}{(1 + 3\alpha)\{3 + \alpha + 2\delta(1 + \alpha)\}} . \quad (12)$$

The factor k has been evaluated and plotted in Figs. 2, 3 and 4, for selected values of the signal-frequency ratio. As to C_0, it is sometimes more convenient to use the formula,

$$\frac{C}{C_0} = 1 - \frac{k . \alpha^2}{\alpha^2 - 1} \quad \ldots \quad \ldots \quad (14)$$

values for which have been plotted in Figs. 5, 6 and 7.

When the outer tracking points are arbitrarily chosen in terms of frequency, it is necessary to calculate the corresponding value of the tuning capacitance variation, C_g, from a knowledge of the total capacitance variation, C'_g. For this purpose we have that,

$$\frac{C_g}{C'_g} = \left(\frac{\omega'_2}{\omega_2}\right)^2 . \left(\frac{\alpha^2 - 1}{\alpha'^2 - 1}\right) \quad \ldots \quad \ldots \quad (19)$$

and it is also useful to remember that

$$\frac{C}{C'} = \left(\frac{\omega'_2}{\omega_2}\right)^2 \quad \ldots \quad \ldots \quad \ldots \quad (18)$$

when it is desired to correlate the signal frequency with the tuning capacitance, at the high-frequency tracking point.

Example I.—Broadcast Band with Extreme Tracking Points

Total frequency coverage = 540 – 1,700 kc/s.

Outer tracking frequencies = 540 and 1,700 kc/s.

Arithmetic-mean tracking frequency = 1,120 kc/s.

Intermediate frequency $= 455$ kc/s.

$$\delta = \frac{455}{1{,}120} = 0.406,$$

$$\alpha = \frac{1{,}700}{540} = 3.15,$$

$$\alpha^2 = 9.9,$$

$$\beta = \frac{1{,}700 + 455}{540 + 455} = 2.165,$$

$$\beta^2 = 4.69.$$

The value of the correction factor (k) may be derived from the chart in Fig. 3, by interpolating between the curves respectively for $\alpha = 3$ and $\alpha = 3.5$, or calculated with greater accuracy from expression (12), which gives

$$k = 0.1455.$$

The value of C is calculated from expression (5), assuming that $C_g = 420$ $\mu\mu$F, and is

$$C = \frac{420}{9.9 - 1} = 47 \ \mu\mu\text{F}.$$

The value of C_0 may be derived from the chart in Fig. 6, by interpolating between the curves respectively for $\alpha = 3$ and $\alpha = 3.5$, or calculated with greater accuracy from expression (11a), which gives

$$C_0 = \frac{420}{(1 - 0.1455)\ 9.9 - 1} = 56 \ \mu\mu\text{F},$$

showing that C_0 is greater than C by 9 $\mu\mu$F.

Finally, for the value of the three-point padder, we have from expression (13) that

$$C_p = \frac{(4.69 - 1)\ (420 + 56)}{(1 - 0.1455)\ 9.9 - 4.69} = 466 \ \mu\mu\text{F},$$

whereas the two-point tracking formula, expression (7), gives a much smaller padder value of

$$C_{p2} = \frac{(4.69 - 1)\ (420 + 47)}{9.9 - 4.69} = 330 \ \mu\mu\text{F}.$$

Example II.—Broadcast Band with Arbitrary Tracking Points

Total frequency coverage $= 540 - 1{,}700$ kc/s.

Arbitrary tracking frequencies $= 700$ and $1{,}500$ kc/s.

Arithmetic-mean tracking frequency $= 1{,}100$ kc/s.

Intermediate frequency $= 455$ kc/s.

$$\delta = \frac{455}{1{,}100} = 0.4136,$$

$$\alpha = \frac{1{,}500}{700} = 2.143,$$

$$\alpha^2 = 4.593,$$

$$\beta = \frac{1{,}500 + 455}{700 + 455} = 1.693,$$

$$\beta^2 = 2.865.$$

It is first necessary to calculate C_g, knowing that $C'_g = 420$ $\mu\mu$F. We have that

$$\alpha' = \frac{1{,}700}{540} = 3.15,$$

$$\alpha'^2 = 9.9,$$

$$C_g = \left(\frac{1{,}700}{1{,}500}\right)^2 \cdot \frac{(4.593 - 1)}{(9.9 - 1)} \cdot 420 = 217 \ \mu\mu\text{F},$$

from expression (19). The remainder of the calculations follows along lines similar to those in Example I.

$$k = 0.103, \text{ from the chart or from (12).}$$

$$C = \frac{217}{4.593 - 1} = 60 \ \mu\mu\text{F, from (5).}$$

$$C_0 = \frac{217}{(1 - 0.103)\ 4.593 - 1} = 69 \ \mu\mu\text{F, from (11a).}$$

$$C_p = \frac{(2.865 - 1)\ (217 + 69)}{(1 - 0.103)\ 4.593 - 2.865} = 426 \ \mu\mu\text{F, from (13).}$$

On comparing these values with those previously derived in Example I, for the same frequency band, it is to be remembered that C and C_0 now contain components due to the movement of the tuning condenser from the extreme high-frequency point (1,700 kc/s) to the outer tracking point (1,500 kc/s). This difference is clearly 13 $\mu\mu$F, for both signal and oscillator circuits, since the constants of the signal circuit must be the same in Example II as in Example I, and the variable condensers used in the signal and oscillator circuits are identical.

Example III.—Short-Wave Band

Total frequency coverage $= 7.67 - 23$ Mc/s ($13 - 39$ metres).

Outer tracking frequencies $= 7.67$ and 23 Mc/s.

Arithmetic-mean tracking frequency = 15.33 Mc/s.

Intermediate frequency = 455 kc/s.

$$\delta = \frac{0.455}{15.33} = 0.0297.$$

$$\alpha = 3\,;\ \alpha^2 = 9.$$

$$\beta = \frac{23 + 0.455}{7.67 + 0.455} = 2.89\,;\ \beta^2 = 8.34.$$

$$k = 0.0155, \text{ from Fig. 4 or expression (12)}.$$

$$C = \frac{420}{9 - 1} = 52.5\ \mu\mu\text{F, from (5)}.$$

$$C_0 = \frac{420}{(1 - 0.0155)\,9 - 1} = 53.5\ \mu\mu\text{F, from (11a)}.$$

$$C_p = \frac{(8.34 - 1)\,(420 + 53.5)}{(1 - 0.0155)\,9 - 8.34} = 6{,}800\ \mu\mu\text{F},$$

from the three-point formula (13), whereas the two-point-tracking padder value is, from (7),

$$C_{p2} = \frac{(8.34 - 1)\,(420 + 52.5)}{9 - 8.34} = 5{,}250\ \mu\mu\text{F}.$$

It is therefore apparent that, although the values of the signal and oscillator trimmers are very nearly equal, as was to be expected, there remains an appreciable difference between the two-point and three-point padder values. Finally it is to be noted that the most likely source of arithmetical error is in the denominator of expression (13) for the padder, in which occurs the difference between two nearly equal quantities. Care taken with this portion of the computations will clearly allow the remainder to be done on a slide-rule.

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Response of Reactive Networks to Frequency-Modulated Signals[*]

By *J. D. Weston*

A PROBLEM which arises in the theory of modulation is that of determining the distortion which a modulated signal undergoes in transmission through a system of linear reactive circuits. That some distortion must occur is obvious, in anything but an ideal network. For design and other purposes, it is necessary to have some knowledge of the general nature of the effects produced in practical networks by the modulation of a sine wave.

One is familiar with the requirements of a system intended to transmit amplitude modulated signals. The case of frequency or phase modulation seems to be less clearly understood. In either case, it is possible to approach the problem by way of the theory of sidebands, in which consideration is given to the spectral distribution of the signal energy. By this method it is possible, knowing the steady-state frequency response of a network, to estimate the relation between the output spectrum and the input spectrum. In the case of amplitude modulation, this result is easily interpreted in terms of the effect on the modulation envelope. For example, symmetrical attenuation of the sideband components farthest from the carrier is equivalent to a relative loss of high modulation frequencies. In the case of frequency modulation, however, the sideband distribution is not so simple and, when the deviation ratio is large, many pairs of sidebands are of importance and the effect on the modulation of relatively attenuating some of them is not so easily perceived. It behoves us, therefore, to consider an alternative way of viewing the problem, appealing more directly to the physical mechanism involved, and permitting a readier visualisation of the principal effects of a varying frequency.

Let us consider the response characteristic of a simple tuned circuit, shown diagrammatically in Fig. 1. This may be referred to as the steady-state characteristic, for it indicates the response to a pure sine wave of any frequency, *f*, provided that this wave has been applied for a sufficiently long time to allow the transient oscillation, which is initiated by switching on, to decay to a negligible amplitude, due to the damping of the circuit. If either the amplitude or the frequency of the wave is now changed, the circuit does not *immediately* respond to the change. A transient oscillation takes place, at the natural frequency of the system, and decays logarithmically at a rate dependent upon the decay factor of the circuit.

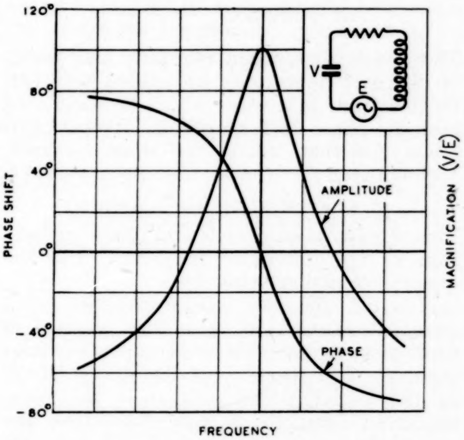

Fig. 1.

When a wave to which the circuit is tuned is subjected to amplitude modulation, this transient effect is in such a phase that it tends to counteract rapid changes in the amplitude of the signal. Thus, if the periodic time of the modulation is short in comparison with the time of decay for the circuit, the modulation will be attenuated. This is another way of looking at the phenomenon of sideband cutting.

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If the frequency of the applied signal is changed quickly, the circuit will not respond in accordance with Fig. 1, owing to the addition of the transient. The effect of this transient may be examined as follows. Let two waves, $\sin \omega t$ and $k \sin (\omega + p)t$, be superimposed on each other. k is the relative amplitude of the smaller signal. We have

$$\begin{aligned} &\sin \omega t + k \sin (\omega + p)t \\ &= (1 + k \cos pt) \sin \omega t + k \sin pt . \cos \omega t, \\ &= a(\cos b . \sin \omega t + \sin b . \cos \omega t) \\ &= a \sin (\omega t + b), \end{aligned}$$

where $$\begin{aligned} a^2 &= (1 + k \cos pt)^2 + k^2 \sin^2 pt \\ &= 1 + k^2 + 2k \cos pt, \end{aligned}$$

and $$\tan b = \frac{k \sin pt}{1 + k \cos pt}$$

That is, the sum of the two waves may be written as

$$(1 + k^2 + 2k \cos pt)^{\frac{1}{2}} \sin \left\{\omega t + arc \tan \left(\frac{k \sin pt)}{1 + k \cos pt}\right)\right\}.$$

This shows that, when two pure sine waves of different frequencies are added together, the resultant is a wave which is modulated in both phase and amplitude. When k is much less than unity, the wave becomes, approximately,

$$(1 + k \cos pt) \sin (\omega t + k \sin pt)$$

This represents amplitude and phase modulation at the difference frequency, the frequency excursion being kp.

Now, in the case of interference by a transient, caused by a sudden change of frequency, the factor k in the above formulae becomes $e^{-\gamma t}$, where γ is the decay factor of the tuned circuit, and t is the time, measured from the instant when the frequency was suddenly changed from $\frac{(\omega + p)}{2\pi}$, the natural frequency, to $\frac{\omega}{2\pi}$. Thus, superimposed upon the impressed change of frequency, there is an evanescent oscillatory change. The importance of this effect can be reduced by making γ large, i.e., by heavily damping the circuit. If the frequency is changed more or less gradually, by a modulating signal, the transient effect or "sluggishness" of the circuit, still gives rise to spurious frequency modulation, i.e., distortion is introduced. The effect of the amplitude modulation at the beat frequency is unimportant because, in a frequency modulation receiver, it is eventually removed by the limiter.

It is now clear that, to obtain the response of a tuned circuit to a varying frequency, it is not necessarily sufficient to assume that impedance formulae which are known to be valid for a steady frequency are also valid when the frequency is replaced, in the formulae, by a varying frequency. However, physical intuition makes it obvious that, if the frequency variation is slow enough, and if the rate of change of response with respect to frequency is not too great, approximately true results can be obtained by assuming the impedance formulae to apply to a varying instantaneous frequency.

This problem has been studied analytically by Carson and Fry, whose results may be summarised as follows. The response of a linear network may be represented by its overall transfer admittance, expressed as a complex function of steady-state angular frequency by the symbol $Y\ (j\omega)$. If, now, the frequency becomes a function of time, the response may be denoted by $Y(j\omega, t)$. This is, in general, different from the "quasi-stationary" admittance, $Y(j\Omega)$, which is obtained by substituting the varying instantaneous frequency, Ω, in the steady-state formulae. But it is shown that

$$Y(j\omega, t) = Y(j\Omega) + \delta(t),^*$$

where $\delta(t)$ is a correction series, containing the time derivatives of the frequency, and the derivatives of Y with respect to Ω. If $\Omega = \omega + \mu(t)$, and $\mu(t) = \lambda s(t)$, where λ is the frequency excursion and $s(t)$ represents the modulating signal, then, if the series converges rapidly we have, taking only the first term,

$$Y(j\omega, t) = Y(j\Omega) + \frac{j\dot{\mu}}{2} . \frac{d^2Y}{d(j\Omega)^2},$$

approximately.

This is very nearly true if λ is large compared with unity, if $-1 \leqslant s(t) \leqslant 1$, and if the derivatives of $s(t)$ are small. In many practical cases, it is sufficient to assume that $Y(j\omega, t) = Y(j\Omega)$. This assumption is

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*"Variable Frequency Electric Circuit Theory." *Bell System Technical Journal*, October, 1937.

generally made in the design of discriminators. If it is valid, the behaviour of band-pass filters may be simply deduced. The admittance $Y(j\Omega)$ may be represented as $\exp[\alpha(\Omega) + j\beta(\Omega)]$, and the input signal as $\exp j\int\Omega dt$. The output signal is therefore given by

$$\exp[\alpha(\Omega) + j\beta(\Omega)] \cdot \exp j\int\Omega dt = \exp\alpha(\Omega) \cdot \exp j[\int\Omega dt + \beta(\Omega)].$$

The amplitude factor, $\exp\alpha(\Omega)$, may be disregarded, since the limiter renders it constant. To determine the effect of the phase factor, we observe that the instantaneous frequency of the output wave is given by

$$\Omega + \frac{d}{dt}\beta(\Omega) = \Omega + \frac{d\beta}{d\Omega}\cdot\dot{\Omega} = \omega + \mu(t) + \frac{d\beta}{d\mu}\mu'(t).$$

Now this is nearly true provided, as we have noted, that the higher derivatives of $\mu(t)$ are negligible and that $\frac{d\beta}{d\Omega}$ is small. By Taylor's theorem we have

$$\mu(t+\tau) = \mu(t) + \tau\mu'(t) + \ . \ . \ .,$$

the terms beyond the second on the right being negligibly small. The modulation of the output frequency is, therefore, $\mu(t+\tau)$, provided that $\frac{d\beta}{d\Omega}$ is constant over the range of instantaneous frequencies present. In other words, there is merely a time delay but no distortion, if the phase characteristic of the network is linear. If it is not linear, considerable distortion may result.

Spectral analysis of a frequency modulated signal shows that, in general, an infinite number of sidebands is present. The limitations imposed above on λ and $s(t)$ imply that most of the energy of the wave lies in the band $\omega \pm \lambda$.

To summarise, we may say that, if the maximum frequency excursion is many times the highest modulation frequency, a reactive network will produce negligible distortion if it has a linear phase characteristic, and an amplitude characteristic which is nearly level over the range $\omega \pm \lambda$, where λ is the maximum frequency excursion. The use of " staggered " tuned circuits to produce the required amplitude characteristic is precluded, since the phase shift is then non-linear.

Correspondence

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain

"The Temperature Compensation of Condensers."

To the Editor, " Wireless Engineer "

SIR,—In the letters published in your May issue some references were made to my article on " The Temperature Compensation of Condensers " and in reply I would first like to thank Mr. Coursey for his remarks on the value of the article and also for pointing out a further feature which precludes the use of a ceramic element for the temperature compensation of a good quality condenser—that of the poor frequency characteristic of permittivity of those ceramics which have highly negative temperature coefficients.

There are, of course, as Mr. Coursey mentions, alternatives to paraffin wax as an impregnant for paper in the manufacture of condensers, a comprehensive reference to which was, however, outside the scope of the article since this was devoted almost entirely to the temperature compensation of condensers of high permanence.

My conception of the effect of excessive humidity upon a ceramic condenser was that of a very large increase of permittivity in very thin surface layers at the boundaries of the electrodes. Presumably Mr. Coursey prefers to regard the effect as an indefinite extension of these electrode boundaries by surface moisture.

I am interested in Mr. Coursey's statement that the ceramic materials used in dielectrics show no water penetration because, if this is so, his conception of the effect of humidity is probably the more correct. The result is the same, however, for whichever the cause the effect is an increase of *apparent* permittivity of the material. Mr. Westcombe states that this humidity effect can be readily overcome by enamelling the surface, but Mr. Coursey says that immunity can be obtained only by complete hermetic sealing in an external ceramic casing and that this method is not readily adaptable to " trimmer " condensers. The ceramic compensator to which I referred in my article is necessarily of the trimmer type and it would therefore be difficult to apply hermetic sealing in this case,

Mr. Coursey, Mr. Tinckham and Mr. Westcombe criticised my statement that it is impossible to adjust ceramic condensers accurately to nominal values. I agree with Mr. Tinckham that the accuracy to which such condensers may be adjusted is comparable with that associated with the *ordinary* silvered mica condenser and is indeed very good for the commercial purposes for which both types are intended. However, the accuracy of ceramic condensers of, say, 1,000 $\mu\mu$F is variously advertised as 10 per cent. to 20 per cent. and accuracies of the order ±1 per cent. are stated as special. In one maker's catalogue 5 per cent. is stated to be a special accuracy. These figures compare very unfavourably with the accuracies *ordinarily* obtained with high-grade mica condensers of the same value. But perhaps I was a little unfair to form a comparison between mica *standards* and *commercial* ceramics, the accuracy of which latter could, no doubt, be improved were there any possibility of employing ceramic condensers as standards.

The commercial ceramic condenser has undoubtedly filled a gap in condenser manufacture since it is particularly suitable for low capacitances of, say, less than 300-500 $\mu\mu$F.

It is less satisfactory for higher capacitances because, naturally, materials having higher permittivity must be employed—materials which have permittivities highly variable with frequency. Such materials usually have temperature coefficients of permittivity which are not only high but also negative and therefore, for the reason given by Mr. Coursey, variable with frequency. Moreover, the power factors of such condensers (10^{-3}) are five times those usually associated with mica *standards* (2×10^{-4}) and may be as much as one hundred times greater than those of good air standards (10^{-5}). For these reasons the ceramic condenser can hardly be regarded as a standard of capacitance.

General purpose standards of capacitance are usually required to have equally low power factors at all frequencies and while this is possible with air and mica standards it certainly is not with ceramic condensers—ceramics being essentially radio frequency dielectrics as stated in my article.

Other features of some ceramics which make them unsuitable for use in *standards* of capacitance such as non-cyclic thermal behaviour, need not be stressed as they are probably of less importance than those already given.

In the penultimate paragraph of his communication Mr. Westcombe criticises my statement that ". . . . the capacitance of the ceramic condenser has a *tendency* to dependence on humidity." That there is at least a tendency is surely admitted in a statement by the makers of the ceramic compensator (which is a ceramic condenser) referred to on page 109 in my article, that "In order to guard against the effects of atmospheric humidity, which tends to increase the capacity and also the loss factor, the regulators are protected by means of an insulating lacquer. This affords certain protection up to at least 80 per cent. relative humidity." I am prepared to agree, however, that by recently developed methods the ordinary *commercial* ceramic condenser of *fixed capacitance* ~~has been rendered sensibly immune from~~ the effect of humidity.

Finally Mr. Westcombe states that I have omitted Dr. Thomas's findings relating to the effect of assembly strains on temperature coefficient. On the contrary I referred on page 106 to Dr. Thomas's findings in his book *Theory and Design of Valve Oscillators*, pp. 154–182—this section of the work deals exhaustively with the subject in question.

Again, the curves B, C, D, and E of Fig. 9, together with line 10 of col. 1, p. 150 and the final paragraph of col. 1, p. 150 fully draw attention to the existence of unexpectedly high (and therefore unpredictable) temperature coefficients.

The expressions which I gave for $\frac{\Delta C}{C}$ on p. 105 were used for the evaluation of the temperature coefficients of very carefully constructed condensers and were certainly only intended for use with fixed value laboratory air condensers of the highest grade.

W. H. F. Griffiths.

Reigate, Surrey.

To the Editor, "Wireless Engineer"

Sir,—Mr. Griffiths' article in the March issue of *Wireless Engineer* contains a number of references to ceramic condensers; some of his statements indicate incomplete contact with modern development.

It is stated that ceramic condensers are still very inferior to the best mica condensers, and that temperature coefficients are of the order of + 150 parts/million/°C. In point of fact, a range of materials is available of both negative and positive temperature coefficient of permittivity. For example, the titania-magnesia type of ceramic, with a permittivity of 16, a power factor (tan δ) of 0.0001 or less, and temperature coefficient of permittivity of + 40 to + 80 parts/million/°C, is a substantially better dielectric than mica for many purposes, particularly as the dielectric properties are maintained over a very wide temperature range.

High-grade radio frequency ceramics are entirely non-porous, and there is no change in permittivity with humidity. Surface films of moisture on exposed ceramic surfaces, or on thin varnish coatings of ceramic condensers certainly, for obvious reasons, cause variation in effective capacitance. As for mica and other condensers, the remedy is to protect the dielectric by an adequate well-sealed outer case; this is standard practice among condenser makers when high stability ceramic condensers are required. It may be mentioned also that ceramics are now available which show great reduction in moisture film formation under high humidity.

Mr. Griffiths states that accurate adjustment of ceramic condensers and inductance coils with deposited turns is impossible. This statement is, of course, inconsistent with experience in normal bulk production of both condensers and inductances.

The use of ceramic condensers for compensating variable air condensers may not be so satisfactory for high grade standards as the other methods indicated. However, a high degree of compensation can be achieved at all settings of the air condenser if an appropriate high-capacitance negative coefficient condenser is used in series, in addition to a small parallel connected compensation.

Incidentally, Mr. Griffiths' reference only to early German ceramics would seem to indicate that he is not acquainted with the range of British materials which have been available for several years.
G. P. Britton

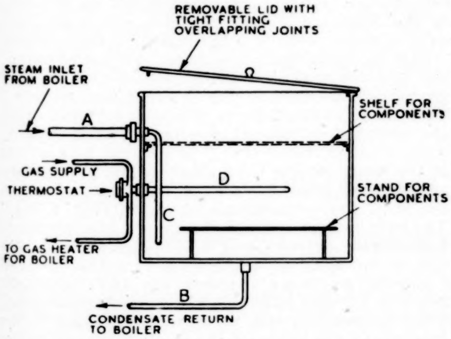
Steatite and Porcelain Products, Ltd.

Humidity Testing of Components.

To the Editor, "Wireless Engineer"

Sir,—Mr. Westcombe has reopened the debate that took place at the I.E.E. in November last, and I feel that his statements call for some further comments and explanation.

In the first place I would emphasise that, in properly designed test chambers, steam is not "blown on to" the radio components at all, but merely serves to saturate the air in the test enclosure. In this connection I did not, perhaps, make it sufficiently clear in the article that the test apparatus arrangement depicted in Fig. 2 in the article does not represent one that is commonly employed in this country. The remarks that I made concerning the greater reliability of the steam injection method were referring primarily to testing apparatus of the type illustrated in Fig. 3 of the article. Unfortunately the angle from which the photograph was taken caused the steam inlet pipe to be obscured. As Mr. Westcombe and others may not be familiar with the apparatus, it may be instructive to amplify the description by the diagrammatic sketch herewith, which shows the interior arrangement in section. The chamber sketched some 18in. cube, made of sheet copper, tinned inside, and polished outside. The lid is removable for loading, and has an overlapping joint as sketched. The water vapour (or wet "steam") is led in through the pipe *A* from the top of the "boiler"—or, as it should more correctly be termed, evaporator. This pipe passes through the side of the chamber close to the top and is turned straight downwards *almost to the bottom* of the enclosure as at *C*. The water vapour or steam is thus not blown on to the components under test, but impinges on to the bottom of the chamber, whence it spreads fairly uniformly over the entire area—as may quite easily be seen by inspection of the "fog" inside which results if cold air is allowed to enter by lifting the lid for a few moments.



Diagrammatic sketch of arrangement of pipe connections to humidity test enclosure.

Articles are not placed on the bottom of the enclosure, but on the stand which is about 3in. above the floor, or on wire mesh shelves as sketched. Temperature control is obtained by the thermostat, the sensitive element of which, in the form of the rod *D*, extends across the back of the enclosure, spaced some 3in. from the side wall.

Tests with such enclosures show that there is never more than 2 deg. C. difference in temperature between any working part of the inside space—naturally excluding actual contact with the sides or lid, and about 1in. away therefrom.

Water vapour condenses freely on the articles under test when they are put cold into the warm wet atmosphere, which is generally considered to be the proper method of carrying out the test. Surplus condensate runs down the sides of the enclosure and drips off the articles, passing back to the boiler by the pipe *B*.

With apparatus of such construction, at least when limited to the size mentioned, a very uniform test atmosphere is obtained.

It is understood, however, that tendency in official quarters is towards circulation of the incoming moisture stream by a fan. The criticism of Mr. Westcombe might apply more rightly to such arrangements than it does to the arrangement here described and illustrated in Fig. 3 of my article.

Secondly, Mr. Westcombe thinks the use of such apparatus cannot simulate even the most extreme tropical conditions. An exactly opposite view was expressed during the discussion at the I.E.E. on this subject in November last. It was there stated that experience has shown that the K110 humidity test, carried out in this way, does very closely simulate average tropical use for about 2 years (apart from any special local conditions such as salt air corrosion, etc.).

Thirdly, I do not quite see the point of Mr. Westcombe's simile of fatigue and tensile strengths. The K110 type of test *is* a fatigue test in that it consists of repeated cycles of temperature and humidity. It most certainly does not have any characteristics of a static test (like his simile of tensile strength)—particularly when it is continued for longer periods, such as the twenty cycles specially mentioned on p. 100 of my article.

Finally, it seems to me that while Mr. Westcombe's test enclosure is better than many arrangements that have been used, it still suffers from the fundamental defect that if evaporation of the water in the bottom of the chamber is to take place, its temperature must be raised above that of the air above its surface. Even with his water jacket arrangement, evaporation will still be required to compensate for the condensation that must always take place since the top of the enclosure is outside the water jacket, and some leakage may also occur around the lid and certainly will take place if the enclosure is opened at all during use. In most testing laboratories dealing with any substantial number of components per day, opening of the enclosure during use can hardly be avoided. A large make-up of moisture in the air must therefore be obtained by evaporation from the enclosed water. Some auxiliary heating in the water then becomes almost imperative if the operating conditions inside the enclosure are to be maintained with any degree of uniformity. My experience has certainly been that this steam injection method gives more reliable, consistent and repeatable results than do evaporation methods from an internal water trough, even although its effects are more severe.

Liss, Hants. PHILIP R. COURSEY.

Book Reviews

Thermionic Valve Circuits

By EMRYS WILLIAMS, Ph.D., A.M.I.E.E. Pp. 174 + viii, with 106 Figs. Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 12s. 6d.

This book is based on a course of lectures to final year degree students in Electrical Engineering, and assumes the preliminary knowledge that such students would possess, but for the benefit of those whose mathematics may be rusty, the first five pages are devoted to a summary of the a.c. theory and mathematics required. Subsequent chapters deal with the valve, amplifiers, regeneration and oscillation, detectors and rectifiers, frequency changers and modulators. The book makes no claim to novelty of treatment; it is based on a selection from larger and more comprehensive works, such as Terman's *Radio Engineering*, of those parts dealing exclusively with thermionic valve circuits.

The book admirably fulfils its purpose. The ground covered and the method of treatment are very suitable for this part of a University course on radio-communication. It is, however, very surprising and unfortunate in a book intended for university students to find the a.c. resistance of a valve referred to throughout as its impedance. This usage is excusable among those who cannot be expected to have much knowledge of a.c. theory but is hardly excusable in a book of this type. The slope of the static characteristic gives a value of $\delta V_a/\delta I_a$ which is sometimes called the differential resistance and sometimes the slope resistance, but to which the British Standards Institution officially gave the name of a.c. resistance. It is obtained from a static characteristic determined with steady voltages and currents; it has nothing to do with inductance or capacitance; it is entirely independent of frequency, and it is universally represented by R or ρ and never by Z. One can easily understand how the non-mathematical person would be misled into thinking that the mysterious symbol $\delta V/\delta I$ could not represent a resistance. To be consistent the author should have called g_m the mutual admittance. The author may plead in extenuation that many of the valve manufacturers use the term, which is true, but a poor argument. Apart from this the book is one that can be thoroughly recommended to the large number of students who are now having, willy-nilly, to study the thermionic valve and its many applications in all our universities and technical colleges.

G. W. O. H.

The Cathode Ray Tube and its Applications

By G. PARR. Pp. 180 with 80 Figs. Chapman & Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 13s. 6d.

One wonders if the author has any conception of the impression made on the average reader when, on the first page of a book making some claim to scientific accuracy, he finds the early work on negatively charged particles attributed to somebody named J. J. Thompson, due presumably to some confusion between J. J. and Silvanus. The addition of "Kelvin" in brackets would have completed the triangle. Perhaps, however, one should not be too critical, as the author explains in the preface that, due to circumstances beyond his control, the revision of the earlier edition had to be suddenly accelerated. The first edition was entitled "The low voltage cathode ray tube," but in this new edition the limitation has been removed. The scope of the book will be seen from the titles of the eight chapters: I. Construction and Operation; II. Focusing and Performance; III. Lissajous' Figures; IV. Linear Time Bases; V. Other Time Bases; VI. Applications to Radio Engineering; VII. Industrial and Other Applications; VIII. Television Reproduction. There is an appendix dealing with Photography. As in the earlier edition, one of the most valuable features is the very complete and extensive bibliography occupying 17 pages. Another valuable feature is the list of components for building up the various circuits described; this will prove very helpful in laboratory work. In many places we felt that the author might with advantage have given a little more explanation. On p. 7, for example, we are told that in the Standard Telephone Co.'s soft tubes, the grid is made positive with respect to the cathode. "This electrode then acts as a 'pre-concentrator,' the positive potential being necessitated by the geometrical position of the cylinder and cathode." There is no explanation as to why it is called a pre-concentrator or how it pre-concentrates. Again, on p. 17 it is stated that "to prevent fluctuations in the beam current from affecting the bias voltage a 'bleeder' resistance should be connected across the H.T. supply terminals as shown (Fig. 8 (b))." The only current through the tapped bias resistance is the beam current, and it is not at all clear how this is modified by the presence of the so-called "bleeder resistance" across the H.T. terminals. Fig 8 (a) appears to be upside down when compared with (b) and (c). On p. 26 with reference to the rotation of the image of the electron source by the field it is stated that "the focusing coil of Fig. 13 (c) is designed to obviate this effect"; but no hint is given as to how it does it. Limitations of space are probably to blame for these shortcomings. In copying Fig. 68 from Cosens' original diagram an essential connection has been omitted.

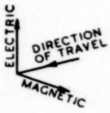
The book contains a great amount of very useful information, and will prove very helpful at the present time when so many cathode-ray tubes are being used in radio and other laboratories. The lists of necessary components will enable one to go to the cupboard and get out the various items, and connect them up in the shortest possible time, while the classified bibliography will enable one to look up the literature on any specific point. G. W. O. H.

D/F Handbook for Wireless Operators

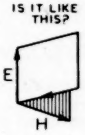
By W. E. Crook. Pp. v + 64 with 85 Figs. Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 3s. 6d.

This is a strictly practical book intended for wireless operators employed at D/F stations. It assumes a knowledge of elementary radio theory. Specific D/F apparatus is not referred to, because, as the author says, nothing would be gained by describing one or two actual sets which will inevitably be obsolete in a comparatively short time. After an introductory chapter on D/F in general, Chapter II deals with the rotating frame, Chapter III with the Bellini-Tosi system, Chapter IV with fixing the sense as well as the direction of the signal, and Chapter V with the various errors and their elimination by the use of Adcock aerials. The final chapter explains the choice of a suitable site for a D/F station and its calibration by means of a local oscillator or by means of aircraft. To judge from the fact that it is not mentioned, we presume that the Robinson D/F coil is a thing of the past.

The book is very well produced, well illustrated, and, we believe, entirely free from misprints. The description of the apparatus and the explanation of the various phenomena and their effects are models of clarity. The only thing that we would criticise is the drawing that is here reproduced as (a). It is Fig. 6 in the book. This can mean either of two diametrically opposite things depending on whether you picture it as an inside or outside view of a corner of a cube. The two alternatives are illustrated in (b) and (c). If one adopts the hand-rule, pointing the first finger along the magnetic field and the second finger along the electric field, then for the thumb to indicate the direction of transmission, (b) corresponds to the lefthand and (c) to the right hand. Which is correct can be seen at once from the simple circuit shown in (d). Here the electric field is upward and the energy transmission from right to left as in the other figures and the magnetic field is seen at once to be away from the observer as in (b) which is therefore the correct picture.



(a)



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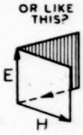

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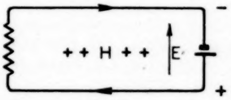

(d)

G. W. O. H.

I.E.E. Wireless Section Committee

THE following nominations have been made to fill the vacancies which will occur on the Wireless Section Committee of the Institution of Electrical Engineers on September 30th :—Chairman, R. L. Smith-Rose, D.Sc., Ph.D. (National Physical Laboratory) ; Vice-Chairman, H. L. Kirke (British Broadcasting Corporation) ; Ordinary Members of Committee, A. D. Blumlein, B.Sc.(Eng.), (Electric and Musical Industries) ; E. C. S. Megaw, B.Sc. (General Electric Co.), and J. A. Smale, B.Sc. (Cable & Wireless).

Wireless Patents

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

542 408.—Automatic biasing arrangement, say for a power amplifier, combined with an additional source of bias as a safeguard against failure of the first.

J. W. Dalgleish and S. R. Poole. Application date 7th February, 1940.

AERIALS AND AERIAL SYSTEMS

542 241.—Frame aerial, particularly for portable sets, in which a series inductance is utilised to reduce the effect of distributed capacitances both between the turns of the aerial, and from aerial to ground.

Philco Radio and Television Corpn. (assignees of W. H. Grimditch). Convention date (U.S.A.) 17th June, 1939.

542 452.—Transmission-line filter, including piezo-electric crystals each capable of resonating at one or other of several frequencies.

Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 10th November, 1939.

542 780.—Transmission-line coupling circuit for

converting push-pull energy into a push-push relation.

Marconi's W.T. Co. (assignees of N.E. Lindenblad). Convention date (U.S.A.) 28th July, 1939.

DIRECTIONAL WIRELESS

542 564.—Direction-finding system in which a magnetic disc rotates with a frame aerial and the poles so induced control the position of a direction-indicating magnet.

Standard Telephones and Cables (assignees of N. E. Klein). Convention date (U.S.A.) 25th October, 1939.

542 584.—Indicator device for a direction finder in which transparent and opaque scales are provided to simplify the taking of a bearing corrected for " sense " and for quadrantal error.

Marconi's W.T. Co. and J. H. Moon. Application date 17th July, 1940.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

542 223.—Inductance and capacitance unit for trimming the tuning of ganged high-frequency stages.

Marconi's W.T. Co.; C. P. Beanland; and C. S. Cockerell. Application date 28th May, 1940.

542 356.—Time-constant circuit inserted in series with the high-tension supply to an amplifier to render it immune from voltage fluctuations.

W. W. Groves (communicated by Automatic Signal Corpn.). Application date 4th March, 1940.

542 395.—Variable inductance which is tuned by uniformly changing the spacing of the coils by altering the pressure of a spring at one end.

The Mullard Radio Valve Co. and C. C. Eaglesfield. Application date 14th August, 1940.

542 469.—Single-valve arrangement including a tuned circuit of variable band-width as determined by the application of positive feed-back to the circuit and negative feed-back to the valve.

E. L. C. White and E. W. Bull. Application date 8th June, 1940.

542 485.—Coupling circuit designed to eliminate the effect of intermediate-frequency instability in a multi-band superhet receiver.

Marconi's W.T. Co.; C. S. Cockerell; J. D. Brailsford; and M. H. Cufflin. Application date 23rd February, 1940.

542 531.—Powdered-core inductance unit which can be tuned over a wide range without any appreciable change in the inductance-resistance ratio or " Q " factor.

Marconi's W.T. Co. (assignees of A. L. Rosenberg, Junr.). Convention date (U.S.A.) 20th July, 1939.

542 611.—Securing a constant " band-spread " effect over a wide frequency range by varying an auxiliary inductance which does not form part of the main tuning circuit but is coupled to it.

The Mullard Radio Valve Co.; F. Caplin; and C. E. Payne. Application dates 9th July, 1940, and 18th February, 1941.

542 675.—Phase-shifting network associated with the grid circuit of a valve and particularly suitable for automatic frequency-control or for frequency modulation.

The General Electric Co. and L. C. Stenning. Application date 2nd August, 1940.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

542 175.—Broad band repeater section, including stabilised negative feed-back for the transmission of television signals or multi-channel carrier systems.

Standard Telephones and Cables (assignees of H. W. Bode). Convention date (U.S.A.) 29th September, 1939.

542 219.—Construction and arrangement of the electrostatic deflecting-plates for preventing distortion in a television transmitting tube using a low-velocity scanning beam.

Marconi's W.T. Co. (assignees of H. A. Iams and A. Rose). Convention date (U.S.A.) 27th May, 1939.

542 258.—System of interlaced scanning for television which readily lends itself to a complete separation of the vertical and horizontal synchronising impulses.

Standard Telephones and Cables (assignees of R. L. Campbell). Convention date (U.S.A.) 19th October, 1939.

242 259.—Television receiver with interlaced scanning in which vertical synchronising impulses are separated from horizontal synchronising impulses, without the latter having to be intermittently blanked out.

Standard Telephones and Cables (assignees of R. L. Campbell). Convention date (U.S.A.) 22nd December, 1939.

542 332,—Television transmitter tube using a low-velocity scanning beam and provided with means whereby only those electrons that have been modulated are utilised for signalling.

Marconi's W.T. Co. (assignees of H. A. Iams). Convention date (U.S.A.) 29th July, 1939.

542 436. — Distribution system for gradually changing-over or " fading " one television scene into another.

Philco Radio and Television Corpn. (assignees of B. E. Schnitzer). Convention date (U.S.A.) 11th May, 1939.

542 626.—Means for securing an automatic amplification control and a stable line-synchronising impulse in television.

Hazeltine Corpn. (assignees of R. L. Freeman and H. L. Blaisdell). Convention date (U.S.A.) 8th December, 1939.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

541 634.—Transmission network comprising three sections in series-shunt for coupling loads of different impedances.

Electrical Research Products, Inc. Convention date (U.S.A.) 4th August, 1939.

541 664.—Electrode arrangement of a discharge tube for generating ultra-short waves by projecting a stream of electrons through a resonating chamber.
Standard Telephones and Cables and F. D. Goodchild. Application date 4th June, 1940.

541 665.—Transmission system in which a common carrier wave is utilised to carry different messages, one by a form of amplitude modulation and the other by a method of phase or frequency modulation.
Standard Telephones and Cables ; W. A. Beatty ; and C. T. Scully. Application date 4th June, 1940.

541 796.—Short-wave radio relay systems in which the signal is received and retransmitted without change of frequency.
Marconi's W.T. Co. (assignees of H. O. Peterson). Convention date (U.S.A.) 30th June, 1939.

541 882.—Means for correcting amplitude and phase distortion in transmission systems covering a wide band of frequencies [addition to 495 815].
Electric and Musical Industries and J. Collard. Application date 13th June, 1940.

542 005.—Transmitting and receiving signals by a method in which the polarisation of the waves in space is made to oscillate about a mean position.
Marconi's W.T. Co. (assignees of G. L. Usselman). Convention date (U.S.A.) 17th June, 1939.

542 226.—" Passive " network for coupling a modulating device to an oscillation-generator without generating parasitic frequencies.
Standard Telephones and Cables (communicated by Le Matériel Téléphonique Soc. Anon.). Application date 30th July, 1940.

542 277.—Grid-modulated oscillator circuit, particularly for low-powered battery-operated transmitters.
J. W. Dalgleish ; S. R. Poole ; and Pye. Application date 7th February, 1940.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

542 182.—Ultra-short-wave arrangement of resonators for first " bunching " a stream of electrons and then drawing power from it.
Marconi's W.T. Co. (assignees of I. Wolff). Convention date (U.S.A.) 21st July, 1939.

542 285.—Construction and arrangement of the split anodes in a high-powered magnetron.
Marconi's W.T. Co. (assignees of G. R. Kilgore). Convention date (U.S.A.) 30th June, 1939.

542 389.—Electron-discharge device of the Klystron type in which a beam of positive ions is utilised to increase the density of a stream of electrons.
Standard Telephones and Cables and H. Motz. Application date 5th July, 1940.

542 390.—Means for neutralising the space charges set up by the electron stream in a resonator tube of the Klystron type.
Standard Telephones and Cables and H. Motz. Application date 5th July, 1940.

542 488.—Means for controlling the intensity of an electron stream by first diverting it from its path and then restoring it to a path parallel with the first.
J. D. McGee ; H. Miller ; and G. S. P. Freeman. Application date 2nd May, 1940.

542 496.—Means for removing from a spiral stream of electrons those travelling in a path of undesirably large radius.
J. D. McGee and G. S. P. Freeman. Application date 2nd May, 1940.

542 497.—Means for centring the electron stream in a cathode-ray tube utilising both electrostatic and electromagnetic deflecting fields.
J. D. McGee and G. S. P. Freeman. Application date 2nd May, 1940.

542 908.—Construction and arrangement of the resonant electrodes of a tube in which an electron stream is first bunched and then utilised as a source of high-frequency energy.
Standard Telephones and Cables (assignees of C. V. Litton). Convention date (U.S.A.) 14th December, 1939.

542 970.—Arrangement for " bunching " the electron stream in an oscillation-generator and for feeding the output to a " horn " aerial or radiator.
Marconi's W.T. Co. (assignees of W. van B. Roberts). Convention date (U.S.A.) 28th July, 1939.

SUBSIDIARY APPARATUS AND MATERIALS

542 245.—Magnifying arrangement for viewing optical images produced by the electron bombardment of a fluorescent screen.
Electric and Musical Industries ; J. D. McGee ; and H. G. Lubszynski. Application date 27th June, 1940.

542 352.—Selector switch for automatically setting a wireless receiver to receive a desired programme at any given time over a sequence of days.
A. B. Thomsen. Convention date (Denmark) 16th May, 1938.

542 366.—Thermionic valve circuit adapted to give a constant output of trapezoidal form irrespective of variations in the applied input.
B. M. Hadfield. Application date 6th July, 1940.

542 806.—Construction and arrangement of a rotary indicator, or tab-holder, particularly suitable as a tuning dial in a wireless receiver.
Philco Radio and Television Corpn. (assignees of J. H. Pressley). Convention date (U.S.A.) 25th July, 1939.

543 000.—Earthing switch for minimising the radiation of " static " disturbance when starting-up an internal-combustion engine.
Bendix Aviation Corpn. Convention date (U.S.A.) 2nd August, 1939.

543 032.—Trembler or vibrator system for transforming the voltage derived from a direct-current source, particularly for the high-tension supply to wireless sets.
Philco Radio and Television Corpn. (assignees of J. H. Pressley). Convention date (U.S.A.) 8th September, 1939.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

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PROPAGATION OF WAVES

1592. Electromagnetic Waves in Metal Tubes of Rectangular Cross-Section.—J. Kemp. (*Elec. Communication*, No. 2, Vol. 20, 1941, pp. 73–79.) *See* 2958 of 1941.

1593. On the Relation between the Inherent Values of Hollow Metal Tubes and Their Miscellaneous Constants [Extension of Work on Rectangular-Section Tubes (1817 of 1941) to Fan-Shaped Tubes, as Example of Cylindrical-Coordinate System].—I. Iwataka. (*Electrotech. Journ.* [Tokyo], March 1941, Vol. 5, No. 3, pp. 58–59.)

1594. Elliptic and Spheroidal Wave Functions [Scalar & Vector Wave Equations: Gegenbauer Functions: General Spheroidal Functions: Prolate & Oblate Spheroidal Functions: Mathieu Functions].—L. J. Chu & J. A. Stratton. (*Journ. of Math. & Phys.* [of M.I.T.], Aug. 1941, Vol. 20, No. 3, pp. 259–309.)

1595. General Amplitude Relations for Transmission Lines with Unrestricted Line Parameters, Terminal Impedances, and Driving Point.—King. (*See* 1743.)

1596. The Calculation of Ground-Wave Field Intensity over a Finitely Conducting Spherical Earth [Summarised Results of 1936/39 Papers, and Graphical Methods (with Curves & Transparent Log-Log Graph Sheets) for Practical Computation, for Vertical & Horizontal Polarisations: Examples of 500 kc/s over Sea Water, 1120 kc/s over Land, & 46 Mc/s over Land: Appendices on Height-Gain Function, etc.].—K. A. Norton. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, pp. 623–639.)

"It has been found experimentally (1597, below) that the departures from these idealised conditions, such as hills, buildings, trees, etc., cause large variations from the calculated values at particular distances, but the theory does provide an excellent guide to the *average* fields encountered in practice."

1597. Field-Intensity Survey of Ultra-High-Frequency Broadcasting Stations [Report to F.C.C.].—E. W. Chapin & K. A. Norton. (Referred to in 1596, above.)

1598. Correction to "The Effect of the Earth's Curvature on Ground-Wave Propagation" [Correction to Expression for Distance Parameter for Horizontally Polarised Waves].—C. R. Burrows & M. C. Gray. (*Proc. I.R.E.*, Feb. 1942, Vol. 30, No. 2, p. 105.) *See* 1834 of 1941.

1599. On the Dielectric Constants of Ionised Gases at Medium Radio-Frequency [Wavelengths 265–827 m: Air & Helium].—S. R. Khastgir & C. Choudhury. (*Indian Journ. of Phys.*, Feb. 1941, Vol. 15, Part 1, pp. 63–71.)

For previous work *see* 92 of 1941. Székely (1930 Abstracts, p. 30) used a resonance method with the test condenser *inside* the discharge tube: conductivity and positive-ion-sheath effects would bring in complications liable to influence the results—which included the obtaining of dielectric constants of ionised air *always* greater than unity. The writers employ a condenser with its plates touching the outer tube surface, and a d.c. discharge from an induction coil. The double-beat procedure was used, with a vernier air condenser made out of a spherometer.

Keeping the wavelength constant at about

700 m and varying the discharge current from 0.25 mA to 1.8 mA (air) and 1.4 mA (helium), ϵ was found to increase from 1.015 to 1.082 (air) and from 1.0062 to 1.038 (helium), the increase being almost linear in both cases for the greater part of the current range but slowing down (for air) beyond about 1.25 mA: a similar lessening of the increase in helium may perhaps be detected at the end of the current range (Fig. 2, top curve) and it is deduced that both for air and helium ϵ "increased linearly with the discharge current except when the latter was large."

Keeping the discharge current constant and increasing the wavelength, it was found that ϵ for both gases decreased slowly and gradually as the wavelength increased, always however remaining slightly greater than unity: whereas test experiments showed that for wavelengths smaller than about 9 m ϵ for ionised air (keeping the discharge current at a small steady value) was definitely less than unity. "This suggests the existence of a resonance frequency for the ionised medium much higher than the medium radio-frequencies employed in these experiments": Gutton's quasic-elastic resonance and Tonks and Langmuir's plasma-electronic resonance would both be possible in the medium inside a discharge tube, the difference being that in the first case $\omega_o{}^2 = \mathrm{A}.N^{\frac{1}{2}}$, and in the second case $\omega_o{}^2 = \mathrm{B}.N$, where ω_o is the resonance frequency higher than the test frequency ω. "Hence it can be seen from the expression for the dielectric constant that if ω is fixed, and N is increased by increasing the discharge current, ϵ would increase proportionately except for the higher currents," when N would be greater and consequently ω_o would be higher, so that ϵ would assume smaller values than those demanded by a linear relation between ϵ and N. "This is exactly what was observed."

1600. ON THE HIGH-FREQUENCY CONDUCTIVITY AND EFFECTIVE DIELECTRIC CONSTANT OF ELECTRONIC MEDIUM IN A HIGH-VACUUM THERMIONIC VALVE.—Basak. (*See* 1688.)

1601. ON THE MOTION OF AN ELECTRIC PARTICLE.—I. Opatowski. (*Journ. of Math. & Phys.* [of M.I.T.], Dec. 1941, Vol. 20, No. 4, pp. 418–424.)

After referring to the work of Störmer and Graef & Kusaka, the writer says: "In the present paper the particle is assumed to move in electric and magnetic fields of a very general form which include the most important fields of mathematical physics (fields symmetric about an axis, plane fields, etc.); forbidden regions are determined and cases are indicated where the equation of motion can be simplified or explicitly integrated": an example deals with a field due to a magnetic dipole and a ring of electricity, and obtains "a forbidden region for the motion of an electric particle due to a simultaneous action of a magnetic dipole, a circular electric current of constant intensity, and an electrostatic charge distributed uniformly over a circle" [of interest in connection with cosmic rays]. Boggio's work (3940 of 1938 and 1130 of 1939) is specially referred to.

1602. A PHOTOGRAPHIC METHOD OF ESTIMATING THE MASS OF THE MESOTRON [and Experimental Support to Carlson & Schein's Assumption that Totality of Cosmic Ray Processes in Atmosphere can be explained as due to Impact of Single Primary Particle].—D. M. Bose & B. Choudhuri. (*Nature*, 14th March 1942, Vol. 149, p. 302.) *See* 2356 of 1941.

1603. NEW RESULTS CONCERNING THE APPEARANCE OF ATOMIC LINES IN THE AURORA BOREALIS.—L. Vegard & E. Tönsberg. (*Gerlands Beiträge zur Geophysik*, No. 3/4, Vol. 57, 1941, pp. 289–309.)

1604. MAXIMUM VALUES OF THE EARTH-CURRENT VOLTAGES IN THE NEIGHBOURHOOD OF THE NORTH AURORAL ZONE DURING VERY INTENSIVE GEOMAGNETIC DISTURBANCES [of March 1940: exceeding 50–60 Volts/Kilometre: Comparison with Disturbance of April 1938].—L. Harang. (*Gerlands Beiträge zur Geophysik*, No. 3/4, Vol. 57, 1941, pp. 310–316.) *Cf.* McNish, 15 of 1941.

1605. IONOSPHERIC INVESTIGATIONS AT HUANCAYO MAGNETIC OBSERVATORY (PERU) WITH APPLICATION TO WAVE-TRANSMISSION CONDITIONS [using Carnegie Institution's Automatic Multi-Frequency Equipment: Analysis of Results in terms of Max. Usable Frequencies for Various Distances].—H. W. Wells. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 667: summary only.)

1606. TEMPERATURE OF METEORS AND DENSITY OF THE UPPER ATMOSPHERE.—J. Hoppe. (*Sci. Abstracts*, Sec. A, Dec. 1941, Vol. 44, No. 528, pp. 375–376.)

1607. WHISTLING METEORS: A DOPPLER EFFECT PRODUCED BY METEORS ENTERING THE IONOSPHERE [Investigation prompted by Observation of Weak Heterodyne Whistles of Unusual Type (High-Pitched Note rapidly Descending in Pitch) in Short-Wave Reception].—Chaman Lal & K. Venkataraman. (*Electrotechnics* [Bangalore], Nov. 1941, No. 14, pp. 28–39: summary in *Nature*, 11th April 1942, Vol. 149, pp. 416–417.)

1608. A POSSIBLE INTERPRETATION OF CERTAIN INTENSE RADIATIONS FROM THE NIGHT SKY IN THE ULTRA-VIOLET REGION [may belong to the Herzberg Bands].—J. Dufay. (*Comptes Rendus* [Paris], 25th Aug. 1941, Vol. 213, No. 8, pp. 284–286.)

1609. THE POSSIBLE PRESENCE OF BANDS OF THE LYMAN SYSTEM OF THE NITROGEN MOLECULE IN THE ULTRA-VIOLET RADIATION OF THE NIGHT SKY.—G. Déjardin. (*Comptes Rendus* [Paris], 8th Sept. 1941, Vol. 213, No. 10, pp. 360–363.)

1610. DAILY SOLAR RADIANT ENERGY AT THE EXTERIOR OF THE ATMOSPHERE.—R. E. Kennedy. (*Sci. Abstracts*, Sec. A, Dec. 1941, Vol. 44, No. 528, p. 376.)

1611. The Motion of Gases in the Sun's Atmosphere: Part II—On the Westward Tilt of Prominences [Usual, though Eastward Tilt & No Tilt can occur: Rejection of Previous Explanations: Explanation based on Initially Radial Projection from Deep Interior].—A. K. Das & B. G. Narayan. (*Indian Journ. of Phys.*, Feb. 1941, Vol. 15, Part 1, pp. 15–26.) *Cf.* d'Azambuja, 1290 of May.

1612. On the Slope of the Tropopause and Its Variations.—L. Cagniard. (*Comptes Rendus* [Paris], 7th July 1941, Vol. 213, No. 1, pp. 34–37.) Further development of 638 of March.

1613. On the Theory of Cylindrical and Spherical Waves in Frictionless Gases and Liquids.—H. Marx. (*Ann. der Phys.*, Feb. 1942, Vol. 41, No. 1, pp. 61–88.) On the physical implications of some of Bechert's results (2361 of 1941 and 20 of January).

1614. The Cinema Integraph in Interreflection Problems.—Hedeman. (*See* 1831.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1615. Aircraft Precipitation-Static Radio Interference.—Starr. (*Journ. Roy. Aeron. Soc.*, April 1942, Vol. 46, No. 376, pp. 127–128: summary only.)

1616. Theory of the Formation of a Lightning Stroke.—S. Szpor. (*Bull. de l'Assoc. suisse des Élec.*, 14th Jan. 1942, Vol. 33, No. 1, pp. 6–15: in French.)

Schonland's hypothesis has been developed quantitatively by Meek & Loeb, " but satisfactory proofs have not been given. On the contrary, various phenomena observed in the laboratory have thrown doubt on the mechanism of the invisible ionising discharge. In the first place it is difficult to explain why the photoelectric ionisation ahead of the front should not assure, without any preliminary ionisation, a rapid development of the channel. On the other hand, the effect of recombination should not be envisaged separately, apart from the contrary influence of thermal ionisation. With a current of about 0.1 A and a gradient up to 30 000 V/cm or even more, according to the theory, the channel is heated by a considerable power, and a strong deionisation is not at all probable.

" It will be shown that the arrests of the strokes can be caused by the diminution of the gradient ahead of the channel front, thanks to the falls of potential along the channel. Since satisfactory data for calculating this gradient are lacking, it will be necessary to direct our studies in this direction. At the same time we shall obtain relations between several quantities: the charge in the preliminary channel, intensity of the primary electric field and length of channel, current of the preliminary discharge, and velocity of propagation of the front. It is evident that these relations can contribute to a more far-reaching explanation of the lightning mechanism.

" Before this study we shall briefly set out the modern theory of the development of the discharge channel, so that the picture may be more complete. The problem of the diameter of the channel requires to be considered with a special attention, in view of the present lack of a satisfactory explanation. In addition, the special conditions of the atmospheric discharges are defined by the primary field and by the influence of rain-drops." Nearly forty literature references are given.

1617. Symposium on Lightning Arresters.—A. Roth, K. Berger, & others. (*Bull. Assoc. suisse des Élec.*, 19th Dec. 1941, Vol. 32, No. 25, pp. 689–711.)

1618. On the Point Discharge in Thunderstorms and Showers [Measuring Equipment, Results, & Deductions: High Space Charges found near Ground are caused by Point Discharges: Potential Drops at Surface yield No Reliable Conclusions as to Distribution in Cloud except in conjunction with Such Measurements: etc.].—C. W. Lutz. (*Gerlands Beiträge zur Geophysik*, No. 3/4, Vol. 57, 1941, pp. 317–333.)

1619. The Potential Drops during Thunderstorms [Comparison of South African & Indian Results with Those at Wahnsdorf & Potsdam, which showed both " Wilson " & " Simpson " Types about equally, but only as Small Percentage of Total Number: Bipole Picture Not Generally Valid: etc.].—M. Krestan. (*Gerlands Beiträge zur Geophysik*, No. 3/4, Vol. 57, 1941, pp. 334–356.)

1620. The Yearly Variation in the Daily Course of the Atmospheric-Electrical Potential Drop in Wahnsdorf and Potsdam. — H. Goldschmidt. (*Gerlands Beiträge zur Geophysik*, No. 3/4, Vol. 57, 1941, pp. 384–395.)

1621. On the Need for, and the Possibility of, an Atmospheric - Electrical Aerology [Utility of Multi-Seater Glider: Use of Parachute-Borne Apparatus: the Mecklenburg " Type 1939 " (weighing only 4.4 kg) with Film-Recording String Galvanometer: etc.].—P. Lautner. (*Gerlands Beiträge zur Geophysik*, No. 3/4, Vol. 57, 1941, pp. 357–364.) With 18 literature references: *see* also 1622, below.

1622. The Measurement of the Potential Gradient and the Space Charge in the Free Atmosphere [and a " Particularly Small & Stable Recording Electrometer " for Throwing from an Aeroplane].—W. Mecklenburg & P. Lautner. (*Sci. Abstracts*, Sec. A, Dec. 1941, Vol. 44, No. 528, p. 379.) *See* also 1621, above.

1623. The Application of New Results concerning Interchange Processes [Atmospheric Turbulence Research: to Two Atmospheric-Electrical Problems, the Distribution of Radioactive Matter in the Atmosphere and the Layer Thickness of the " Electrode

Effect" for Linear Interchange-Variation with Height].—H. Lettau. (*Gerlands Beiträge zur Geophysik*, No. 3/4, Vol. 57, 1941, pp. 365–383.)

1624. Condensation Nuclei and Small Ions in the Air of Col d'Olen (2900 m above Sea Level): *also* Investigations on Heavy Ions in the Atmosphere: III [including Connection with Relative Humidity & Visibility], *and* Ions and Nuclei, a Critical Study.—G. Aliverti: H. Israël: H. Israël. (*Gerlands Beiträge zur Geophysik*, No. 3/4, No. 57, 1941, pp. 239–282.)

1625. On the Calculation of the Ionisation Equilibrium in Nucleus-Carrying Air.—E. von Schweidler. (*Gerlands Beiträge zur Geophysik*, No. 3/4, Vol. 57, 1941, pp. 283–288.)

1626. "Weather Analysis and Forecasting: a Textbook on Synoptic Meteorology" [Book Review].—S. Petterssen. (*Nature*, 21st March 1942, Vol. 149, pp. 313–314.)

PROPERTIES OF CIRCUITS

1627. On the Coupled Oscillations of a Harmonic Oscillating Circuit and a Generator of Discontinuous Oscillations [*e.g.* Dynatron], *and* The Fluctuations in Auto-Oscillating Systems and the Determination of the Frequency Deviations of a Valve Oscillator.—Kholodenko: Berstein. (*See* 1648 & 1649.)

1628. Stability of Oscillations in Systems obeying Mathieu's Equation.—Brainerd. (*See* 1646.)

1629. *L-R* and *C-R* Sections are Degenerate Oscillatory Circuits.—E. de Gruyter. (*Bull. Assoc. suisse des Élec.*, 14th Jan. 1942, Vol. 33, No. 1, pp. 19–22: in German.)

"These considerations form an appendix to my series of articles on the oscillatory circuit. The last article appeared in this journal in the issue No. 21 of 1941, in whose bibliography the other articles can be found [*see* 1840 & 4333 of 1939 and 333 of 1941]. It is shown that the 'resistance-reactance combination' is the concept which covers oscillatory circuits, $L + R$ elements, and $C + R$ elements, as regards impedance and phase. The fact that the reactance may be purely inductive, purely capacitive, or mixed, plays in principle no rôle in the representation of this concept. The 'effective frequency' and the 'zone of influence' of the circuits considered are defined in terms of the 'time constant.' Finally, a representation is given of the frequency characteristic corresponding to the physiology of the human ear, together with an indication of some technical applications."

1630. Series-Resonance Circuit, Coupled Circuits, and Band-Filters: Corrections.—E. de Gruyter. (*Bull. Assoc. suisse des Élec.*, 21st Nov. 1941, Vol. 32, No. 23, p. 622.) Corrections to the last article, in No. 21, mentioned in the above abstract, 1629.

1631. On the Temperature Coefficient of the Equivalent-Circuit Constants in Quartz Crystal Vibrators for Electrical Wave-Filters.—Z. Kamayachi & T. Ishikawa. (*Electrotech. Journ.* [Tokyo], Feb. 1941, Vol. 5, No. 2, p. 35.)

"Few exact values for $(1/d_{11}) . (\partial d_{11}-/\partial T)$ have been published. However, as it can be imagined that it has a negative value in the neighbourhood of the ordinary temperature, it must be safe to say from eqns. 5 & 6 that values of L and C vary respectively in opposite directions by the variation of temperature in this vibrator. The results of the authors' experiments agree with this conclusion, and these coefficients have been found to have large values of the order of one thousandth . . . A vibrator having a low temperature coefficient of frequency has not always low temperature coefficient of constants L and C . . ."

1632. A Quartz Plate with Coupled Liquid Column as a Variable Resonator.—Fox & Rock. (*See* 1756.)

1633. A New Principle for Stable Direct-Current Amplification [for Process Control & Many Other Purposes].—R. Eberhardt, G. Nüsslein, & H. Rupp. (*Arch. f. Elektrot.*, 30th Sept. 1941, Vol. 35, No. 8, pp. 477–489.)

Theoretical treatment of the problem dealt with in 3588 of 1941. Authors' summary:—"After a short survey of the previous development of d.c. amplifiers for measuring purposes, leading to-day to the photocell-compensator [*loc. cit: see* also Bleckwenn, 1133 of April], the paper discusses the fundamental considerations concerning opposed-coupling [negative-feedback] d.c. amplifiers. Two main types are dealt with, the voltage amplifier and the current amplifier. By a very high opposed-coupling factor a 'compensation' of the quantity under measurement at the input terminals is obtained. By this compensation the input resistance is considerably increased, in the voltage amplifier, and decreased, in the current amplifier. The output resistance providing the negative feedback can be made either very small or very large by the choice of a suitable connection, according to whether the output is required to deliver a constant voltage or a constant current. The voltage or current amplification factor can be made as constant as desired by choosing a sufficiently high opposed-coupling factor.

"Formulae for the power amplification with and without opposed coupling are derived. Interfering voltages penetrating anywhere in an opposed-coupling amplifier are reduced more and more in their effect on the indicating instrument, the greater the amount of amplification in front of their point of entry. In a subsequent second part, practical results with such amplifiers will be reported."

1634. Optimum Conditions for Maximum Power in Class A Amplifiers [Four Cases, giving $R = r_p$, $R = 2r_p$, $R \doteqdot 20r_p$ (Fixed Quiescent Plate Dissipation), & $R \doteqdot 8r_r$ (Quiescent Plate Voltage & Dissipation both Fixed)].—W. B. Nottingham. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, pp. 620–623.)

1635. The Absolute Sensitivity of Radio Receivers [and the Rating & Measurement of Noise].—North. (*See* 1656.)

1636. On the Corpuscular Treatment of the Thermal Noise of Electrical Resistances.—E. Spenke. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 2, Vol. 18, 1939, pp. 54–72.)

Bernamont (1715 of 1937) investigated the elementary processes underlying this noise effect, seeing as its cause the individual current pulses produced by the random to-and-fro motions of the conduction electrons, and showing that from this viewpoint also the Nyquist formula could be obtained. "The present work has for its first task the carrying through of the corpuscular treatment of thermal resistance-noise by more primitive mathematical methods [based on Fourier analysis of the independent single process] than those of Bernamont, perhaps at the cost of the strictest mathematical rigour. Further, the path-time effects of the electrons are taken into consideration. It is found that the ohmic resistance has the same variation with frequency as the mean square of the effective voltage value (' Rauschquadrat '), so that by employing the resistance value for the particular frequency in question the formula for the mean ' Rauschquadrat ' retains its form even for high frequencies, whereas if the resistance value for zero frequency is used a frequency-dependent factor must be introduced : for the case of a Maxwellian velocity-distribution and mean free-path-lengths independent of velocity this factor has the value given by Bakker [in his 1938 U.R.S.I. paper, ref. " 5 "]. Finally, some difficulties are discussed which occur if the free path of an electron is considered as an independent elementary act."

In a final footnote the writer discusses the contemporary paper by Bakker & Heller (1842 of 1939) in which these workers give the derivation of the frequency formula for the mean " Rauschquadrat," only stated without derivation in Bakker's previous paper : using for this purpose an equation (involving a " correlation function ") given by Ornstein & Uhlenbeck : no reference is given here but the paper is presumably that referred to in 1931 Abstracts, p. 167, l-h column. In this way, the present writer points out, one of the difficulties which he has discussed (concerning the Fermi-Dirac and Bose-Einstein statistics) is avoided. On the other hand Bakker & Heller kept throughout their work to the ohmic resistance $R(0)$ for frequency 0, and consequently failed to notice that by using the $R(\omega)$ for frequency ω the Nyquist formula remains valid at high frequencies, as indicated in Nyquist's original paper from thermodynamic reasoning and proved in the present paper from corpuscular considerations. Bakker & Heller's adherence to $R(0)$ was prompted by ideas of capacitive shunts, but these do not interfere with the calculation of the mean square of the effective value, for reasons given.

1637. Laplace Transformation and Operational Calculus.—K. W. Wagner. (*Arch. f. Elektrot.*, 30th Sept. 1941, Vol. 35, No. 8, pp. 502–506.)

Author's summary :—" In the technical literature the Laplace transformation is used in two different ways. The one leads to the operator function, well known from its practical applications, the other employs the purely mathematically defined ' image function ' [G. Doetsch, who in his 1937 book " showed that switching problems could be solved from the theory of thermal conduction and electrical lines by transformation by means of the Laplace integral "]. It is shown that both methods of calculation possess the same fields of application and validity, and that the choice between them is purely a matter of convenience. This question is examined from the standpoint of technical and physical applications : the resulting views are overwhelmingly in favour of the use of the operator function."

1638. A Basis for the Complex Calculation of Alternating-Current Problems.—M. Landolt. (*Bull. Assoc. suisse des Élec.*, 19th Dec. 1941, Vol. 32, No. 25, pp. 721–723 : in German.)

" Harmonic oscillations of the same frequency can be replaced unequivocally by complex quantities. This coordination possibility still exists if sums and differences occur, but it fails for products and quotients. In an appendix the writer shows how the relations can be described with the help of some fundamental concepts of higher algebra." The subject has already been treated in another way by Quade (*Deutsche Mathematik*, Vol. 2, No. 1, pp. 18–31). For a criticism of a paper by Voigt on "a.c. power in symbolic representation " see *ibid.*, p. 734, where Voigt replies.

1639. The Algebra of Two-Terminal Networks consisting exclusively of Two-Pole Circuits.—V. I. Shestakov. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 11, 1941, pp. 532–549.)

This is an extract from a larger work by the author in which it was shown that there is a simple and mutual relationship between A-networks, *i.e.* networks consisting exclusively of two-terminal circuits, and A-formulae, *i.e.* formulae whose terms are symbols of the component two-terminal circuits. These terms are related to each other by two mathematical operations only, addition and harmonic addition. It is, therefore, possible to write down an A-formula for any given A-network, and conversely to build up an A-network corresponding to a given A-formula. It is also possible to derive the required modification of an A-network by purely mathematical operations. The present paper is confined to a discussion of the algebraic properties of A-networks. It is also shown that Bul's [presumably Boole, the Irish mathematician] algebra is applicable in the case of " degenerate " A-networks, *i.e.* networks of conductivity equal to 0 or ∞. Thus in designing relay circuits operating from a given combination of impulses full use can be made of Boole's algebra. Boole's methods are apparently those used by Piesch in the papers referred to in 810 and 967 of 1940 ; they are also dealt with in a Russian book on probability theory.

1640. Non-Linear Distortions of Several Sinusoidal Oscillations in Iron [New Method of Treatment giving Calculations as Simple as Those for Valves, Rectifiers, & Similar Non-Linear Elements without Hysteresis: Application to Multiple Telegraphy, etc.].—F. Strecker. (*E.N.T.*, Oct. 1941, Vol. 18, No. 10, pp. 226–238.)

1641. The Graphical Determination of the Resultant Resistance of Several Parallel Resistances [or Resultant Capacitance of Several Condensers in Series].—E. Koplin. (*E.T.Z.*, 30th Jan. 1941, Vol. 62, No. 5, p. 99.)

TRANSMISSION

1642. A Tentative Proposition on the Mechanism of Electronic Oscillations [Prefatory Report on a General Investigation taking Secondary Electrons & Space Charge into Consideration: the Formulation of a Simple Ideal Oscillator Valve which, *mutatis mutandis*, represents "Osaka" Valve (925 of 1937), Farnsworth Secondary-Emission Oscillator, Heil Tube, Klystron, & B-K Oscillator: Some Deductions].—S. Asai. (*Electrotech. Journ.* [Tokyo], March 1941, Vol. 5, No. 3, pp. 59–60.)

1643. On Space-Charge Effects in Velocity-Modulated Electron Beams [Criticism of Webster's Assumptions: Formulation of Two Mathematical Models taking Effect of Space Charge into Account, (i) for Discussion of Working of V.M. Tubes as H.F. Amplifiers, and (ii) "Domain" Model to give Simple Analysis of "Bunching"].—W. H. J. Fuchs & R. Kompfner. (*Proc. Phys. Soc.*, 1st March 1942, Vol. 54, Part 2, No. 302, pp. 135–150.)

(i) Below a certain critical length the beam can operate in the same manner as a beam of particles on which no space charge is acting: the chief effect of space charge is an increase in the mean transit time: formulae valid for no space charge represent good first approximations if $T' = l/v_0$ is replaced by the actual mean transit time T. Above the critical length, the space charge prevents the formation of a continuous beam. (ii) There will be overtaking and proper bunching, with attendant split-bunching, when the current density is below a critical value: above this value there will be no proper bunching, only "compression," the mutual repulsion of electrons preventing any overtaking: if the current density is taken too high, the current peaks will become low and flat.

Ramo's "electronic wave theory" (1378 of 1940) is mentioned as much superior to the elementary theory here developed, in so far as it takes account of the finite cross section and the influence of the screening boundary of the drift space. But his boundary conditions (infinite length of beam, variation of electron velocity with distance from axis) are not satisfied in reality, so that the results can only be regarded as qualitative. "Since our discussion of velocity-modulated beams is physically more intuitive and mathematically simpler than Ramo's, we hope that the publication of the present paper may still serve a useful purpose."

1644. A Stabilised Frequency-Modulation System [with Centre Frequency directly controlled by Single Crystal: Distortion Correction permitting Large Angles of Phase Shift at Phase Modulator, with Low Distortion, resulting in Simpler Apparatus and Reduction of Noise].—R. J. Pieracci. (*Proc. I.R.E.*, Feb. 1942, Vol. 30, No. 2, pp. 76–80.)

1645. The R.C.A. 10-Kilowatt Frequency-Modulated Transmitter.—E. S. Winlund & C. S. Perry. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 667: summary only.)

1646. Stability of Oscillations in Systems obeying Mathieu's Equation.—J. G. Brainerd. (*Journ. Franklin Inst.*, Feb. 1942, Vol. 233, No. 2, pp. 135–142.)

"Equation 2 [$d^2y/dt^2 + \epsilon(1 + k \cos t)y = 0$] occurs in studies of modulation (Carson, *Proc. I.R.E.*, Vol. 10, 1922 [not 1932 as given]: Brainerd, 2959 of 1940), in circuit problems such as the one outlined above [linear varying-parameter system], and in many non-electrical problems of technical importance. It is thus desirable for practical purposes to have the solution of (2) at hand for various ϵ, k pairs. At the present time such solutions are not available, but a gradual approach to their attainment is being made (617 of 1941). The purpose of this paper is to present curves which will facilitate the obtaining of these solutions by giving values of the characteristic exponent μ, defined below. These curves serve both to delimit the stable and unstable states and to give μ for a wide range of the stable state."

1647. The Modulation and Demodulation Method using the Condensers of Periodically Varying Capacity [with Applications to Remote Measurement & Secret Communication: Analysis].—T. Tomituka. (*Electrot. Journ.* [Tokyo], March 1941, Vol. 5, No. 3, pp. 43–44.)

1648. On the Coupled Oscillations of a Harmonic Oscillating Circuit and a Generator of Discontinuous Oscillations.—A. P. Kholodenko. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 11, 1941, pp. 277–301.)

A short survey of the literature on the subject is given and a theory of the operation of such a system is proposed. The discussion is confined to systems satisfying certain conditions, of which the most important are that the harmonic oscillating circuit should have a very low damping and that its natural frequency should not differ appreciably from the natural frequency, or a harmonic, of the generator of discontinuous oscillations. As an example of such systems a dynatron oscillator D coupled to a parallel resonant circuit 2 (Fig. 1) is considered in detail. The coupling between the two circuits is effected through a mutual inductance M_{12} and an amplifier A. The grid circuit of the amplifier is inductively coupled to the resonant circuit, while its anode circuit is resistance-coupled to the anode circuit of oscillator D. Equations (43) and (44) determining the operation of the system are derived, as well as shortened equations (63) and (64.) The stationary states of the system corresponding to the appearance of stable oscillations are investigated, and the amplitude, frequency, and stability of the oscillations are determined. The effect of the parameters of the system on the amplitude and frequency of the oscillations is discussed. The operation of the system prior to the appearance of stable oscillations (non-stationary states) is also examined. Brief reference is made to other systems (Figs. 12 and 13) to which the theory expounded in the present paper is not applicable, and the paper ends with a report on experiments to verify the theoretical conclusions reached.

1649. THE FLUCTUATIONS IN AUTO-OSCILLATING SYSTEMS AND THE DETERMINATION OF THE FREQUENCY DEVIATIONS OF A VALVE OSCILLATOR.—I. L. Bershteyn [Berstein]. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 11, 1941, pp. 305–316.)

The fluctuations in an oscillating system of the Thomson type due to momentary casual changes in the parameters of the system are considered. The dynamic equations of the system (1 and 2) are written down and analysed, using the van der Pol method. The corresponding Einstein-Fokker equation (18) is also derived. The cases of " isotropic " and " non-isotropic " fluctuations are considered separately, and for each case methods are indicated for determining the width of the frequency band generated by the system, as well as the amplitude and phase fluctuations. The purely mathematical discussion is illustrated by considering a physical circuit, a valve oscillator with the tuned circuit connected in the anode circuit (Fig. 1). The possibility of an experimental verification of the theory is also discussed and indicated.

1650. VARIABLE-FREQUENCY BRIDGE-STABILISED OSCILLATORS [incorporating Thermal Device for Amplitude Control].—W. G. Shepherd & R. O. Wise. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 666 : summary only.)

1651. A NEW AIR-COOLED 5-KILOWATT BROADCAST TRANSMITTER [Westinghouse].—F. W. Fischer. (*Proc. I.R.E.*, Feb. 1942, Vol. 30, No. 2, pp. 72–75.)

RECEPTION

1652. SIMULTANEOUS AURAL AND PANORAMIC RECEPTION.—Wallace. (*See* 1702.)

1653. THE AUTOMATIC TUNING OF AMPLIFYING STAGES [where Incoming Frequency may Vary over Wide Ranges, as in Distance-Determining Technique].—Yuzvinski. (*See* 1703.)

1654. COMMON-CHANNEL INTERFERENCE BETWEEN TWO FREQUENCY-MODULATED SIGNALS [Analysis, with Results which have been Verified by Tests].—H. A. Wheeler. (*Proc. I.R.E.*, Jan. 1942, Vol. 30, No. 1, pp. 34–50.)

Subdivision into frequency and amplitude effects : beat-note interference cannot be reduced much by avoiding amplitude effects, can be reduced by using band-width of f.m. exceeding twice that required by modulating signal : cross-talk interference (amplitude effect) minimised by limiter, its amplitude from linear rectifiers only half that from square-law : use of " conical patterns " for tests etc. For previous work on f.m. *see* 1876 & 3297 of 1941.

1655. AN ANALYSIS OF THE SIGNAL/NOISE RATIO OF ULTRA-HIGH-FREQUENCY RECEIVERS.—E. W. Herold. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 665 : summary only.)

Ratio depends on antenna noise, on equiv. noise-resistance/input-resistance of first valve (when band-width is not a consideration) and on input-capacitance × equiv. noise-resistance (when it is a major consideration) : optimum antenna/first-valve coupling (often considerably different from adjustment for max. gain) : thermal noise from wide-band inter-stage circuit made negligible by concentrating all the damping on secondary side : etc.

1656. THE ABSOLUTE SENSITIVITY OF RADIO RECEIVERS [and a Method of Rating & Measuring the Noise in Complete Receiving Systems (particularly U.H.F.) including Aerials : Study of Receiving Aerials, yielding Alternative Derivation of Nyquist's Theorem].—D. O. North. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 665 : summary only.)

" The total random noise originating in a receiver has customarily been described in terms of the equiv. noise voltage at the receiver input terminals. A comparison of the signal/noise ratios of two receivers working out of identical antennas is thereby facilitated, but only as long as the coupling between antenna and receiver input is extremely loose."

1657. ON THE CORPUSCULAR TREATMENT OF THE THERMAL NOISE OF ELECTRICAL RESISTANCES.—Spenke. (*See* 1636.)

1658. THE DETECTION OF A CONTINUOUS SPECTRUM.—I. L. Bershteyn [Berstein]. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 11, 1941, pp. 302–304.)

A mathematical discussion in which methods are indicated for determining the result of square-law detection when a continuous frequency spectrum is applied to the grid of the valve.

1659. ON THE MEASUREMENT OF HIGH-FREQUENCY INTERFERENCE.—F. Conrad. (*E.N.T.*, June 1941, Vol. 18, No. 6, pp. 126–133.)

Steudel & Müller's work (1933 Abstracts, pp. 510–511, and 969 of 1937), which is briefly discussed here, has done much to solve the problem of the l.f. portion of a h.f. interference measuring apparatus, but leaves a number of questions to be answered regarding the h.f. side. Two difficulties in particular remain : first, the curve form of h.f. interference is in general unknown, both that directly at the source and that after conduction along lines or after radiation : such determinations have not been made so far and would be difficult, and yet the knowledge is needed in order to be able to say at what amplitudes a measuring equipment will still act correctly. Secondly, various observations on h.f. receivers working close to interfering sources have shown that oscillations in the ultra-short or even in the decimetric-wave region may appear from any ordinary source and will, unless the apparatus is adequately shielded, upset the measurements.

A measuring device with which repeatable h.f. interference amplitudes can be measured with regard to their noise-level after demodulation must to all intents be identical, right up to the rectifier, with a standard receiver. The whole equipment must therefore consist of a h.f. voltage divider with as high an ohmic input resistance as possible, a h.f. amplifier, rectifier, and sound-level indicator. The writer discusses the question of receiver band-width, the use of "straight" or superheterodyne circuits (the latter have the advantage of a constant band-width, but require steps to be taken to cut out image-frequencies), and the rectifier characteristic. With regard to the latter, it is seen that there can be no proportionality between the amplitudes at the grid of the input valve and the indications of the noise-level instrument, if the rectifier is over-controlled. This means that automatic recording of uncontrolled interference (*e.g.* from power mains or atmospherics) is only possible to a limited extent. This difficulty is perhaps best dealt with by controlling the h.f. input so that the deflection of the noise-level meter is kept constant. Further consideration shows also that it is practically impossible to get consistent results with different equipments unless these are electrically and electro-acoustically identical in all their parts; except perhaps in the case of continuous interference such as glow-discharge or commutator noise. Various other points are discussed, and a fundamental lay-out of an equipment is given in Fig. 5, without any details whatever. It is stated that a number of problems discussed in a previous paper (1934 Abstracts, p. 380) have been solved in the mean-time, but the one relating to wave-form remains unsolved.

1660. Official Production of a Portable Interfering-Voltage Measuring Apparatus [to check that ASE-UCS Limit of 1 mv for Low-Power Machines & Appliances is Not Exceeded].—(*Bull. Assoc. suisse des Élec.*, 29th Aug. 1941, Vol. 32, No. 17, p. 424.) For a further note *see* No. 24 (5th Dec. 1941), p. 678.

1661. A Note on the Sources of Spurious Radiations in the Field of Two Strong Signals [resulting from Non-Linearities in Conductors which serve as Antennas: Special Susceptibility of A.C. Receiver which is Not Earthed ("Electrical-Distribution-System Grounds are Notorious for Rectification"): Methods of Reduction: etc.].—A. J. Ebel. (*Proc. I.R.E.*, Feb. 1942, Vol. 30, No. 2, pp. 81–84.) *See* also 1029 of April.

1662. Aircraft Precipitation-Static Radio Interference.—Starr. (*Journ. Roy. Aeron. Soc.*, April 1942, Vol. 46, No. 376, pp. 127–128: summary only.)

1663. Whistling Meteors: a Doppler Effect produced by Meteors entering the Ionosphere [Weak Heterodyne Whistles of Unusual Type in Short-Wave Reception].—Lal & Venkataraman. (*See* 1607.)

1664. Methods of H.F. Interference Suppression for Machines and Appliances up to 500 Watts [General Principles (Symmetrical & Asymmetrical Interference Voltages): Condenser Connections: Condenser Requirements (including the "Cord" Condenser): Practical Examples].—K. Kegel. (*AEG Mitteilungen*, Sept./Oct. 1941, No. 9/10, pp. 238–244.)

1665. Electrical Interference to Broadcast Reception [in India: Special Conditions due to Wide-Spread Use of Ceiling Fans, Pumps, Refrigerators, etc., chiefly on D.C: Specially Developed Method of Interference Measurement: Effects of Speed Regulation: Polarisation of Interference Signals: Signal/Total-Noise Ratio on Various Wave-Bands: etc.].—S. P. Chakravarti & N. L. Dutt. (*Indian Journ. of Phys.*, Oct. 1941, Vol. 15, Part 5, pp. 365–387.)

1666. On the Fading Reduction in the Space Diversity Reception [Improvement Factor found to be proportional to about $N^{1\cdot 4}$ and to Logarithm of n: Improvement Factor on Optimum (Least Attenuated) Frequency, for Given Distance, is Smaller as Frequency is Higher].—M. Nakagami & others. (*Electrotech. Journ.* [Tokyo], Feb. 1941, Vol. 5, No. 2, pp. 36–37.) Where N is the fading ratio for one aerial and n is the number of aerials.

1667. Some Observations on Space Diversity Effect by Photometry [for obtaining the Statistical Characteristics: Outputs from Two Aerials (after Amplification & Logarithmic Compression) led to Two Sets of C.R.O. Deflecting Plates: Movement of Bright Spots photographed and Density on Film measured Photometrically: Some Results: even with Spacing of only One Wavelength, Fading does Not necessarily Synchronise]. — M. Nakagami & others. (*Electrotech. Journ.* [Tokyo], Feb. 1941, Vol. 5, No. 2, p. 39.)

1668. The Operation of Frequency Converters and Mixers for Superheterodyne Reception.—Herold. (*See* 1690.)

1669. Superheterodyne Tracking Charts: II. —Ruby Payne-Scott & A. L. Green. (*A.W.A. Tech. Review*, Dec. 1941, Vol. 5, No. 6, pp. 251–274.)

In Part I (87 of January) it was assumed, for simplification, that the capacitance in shunt with the oscillator coil was negligibly small; in the present paper the problem of the distribution of stray and trimming capacitances in the oscillator circuit is considered "and is found to lead to some interesting conclusions." Part I is reprinted in this issue of *Wireless Engineer*, and Part II will appear in July.

1670. Standard Tests on Broadcast Receivers [based on R.M.A. 1936 Standards & I.R.E. 1938 Standards].—V. V. L. Rao. (*Electrotechnics* [Bangalore], Nov. 1941, No. 14, pp. 40–49.)

1671. The Swiss Radio Exhibition at Zurich [Glass-Base Valves: Push-Button Tuning (chiefly without Motor Drive or A.T.C.): Automatic Selectivity Control: Economy in Materials: Interference Reduction by Special Aerial: etc.].—(*Bull. Assoc. suisse des Élec.*, 12th Sept. 1941, Vol. 32, No. 18, pp. 443–444.)

1672. Tropical Climate and Communication Technique [with Data (Temperature, Humidity, etc.) for Various Tropical Regions: Insulation Troubles: Damage by Dust Storms, Insects: etc.].—W. M. H. Schulze. (*E.N.T.*, June 1941, Vol. 18, No. 6, pp. 134–147.) A shortened version will appear in the July *Wireless Engineer*.

1673. Some Aspects of the Impact of War Economy on Civilian Radio [Symposium].—L. C. F. Horle & others. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 603: summaries only.)

1674. Civilian Receiver Design in 1942 [and the Place of the Minimum of 7½ Million Broadcast Receivers in the Defence Programme, for the Morale-Building Propaganda Machine: Necessary Standardisation, Materials Substitution, Cooperation, etc.].—D. D. Israel. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, pp. 649–653.)

AERIALS AND AERIAL SYSTEMS

1675. Radiating System for 75-Megacycle Cone-of-Silence Marker [for Canadian Airways: with Sharper Vertical Beam and Smaller Orientation Effect].—E. A. Laport & J. B. Knox. (*Proc. I.R.E.*, Jan. 1942, Vol. 30, No. 1, pp. 26–29.)

1676. Elliptic and Spheroidal Wave Functions.—Chu & Stratton. (*See* 1594.)

1677. Radiation Energy and Earth Absorption with Dipole Aerials.—A. Sommerfeld & F. Renner. (*Ann. der Phys.*, Feb. 1942, Vol. 41, No. 1, pp. 1–36.)

"In text-book literature, which agrees mainly with the Hertz-Zenneck formula, this influencing of the radiation resistance by the ground and by the position of the aerial with respect to this is not spoken of. We consider, therefore, that the elucidation of these points forms the principal result of our work." A full translation is being prepared for immediate publication in *Wireless Engineer*.

1678. The Mayerl Process for the Impregnation of Wooden Masts [in Position].—V. Friesz. (*E.T.Z.*, 12th Feb. 1942, Vol. 63, No. 5/6, pp. 73–74: summary only.)

1679. "Der Leitungsmast aus Holz . . ." [The Wooden Overhead-Line Mast: Its Material, Its Animal & Vegetable Destroyers, Its Impregnation & Maintenance: Book Review].—B. Fenske. (*Bull. Assoc. suisse des Élec.*, 19th Dec. 1941, Vol. 32, No. 25, p. 737.)

VALVES AND THERMIONICS

1680. Space-Charge Relations in the Magnetron with Plane Electrodes.—E. A. Condon. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 664: short summary only.)

1681. Theory of the Magnetron [Study of Magnetron in Static Condition, with Strict Regard to Influence of Space Charge].—L. Brillouin. (*Elec. Communication*, No. 2, Vol. 20, 1941, pp. 112–121.) Paper prepared in Jan. 1939: for a later work *see* 107 of January.

1682. The Design and Development of Three New Ultra-High-Frequency Transmitting Tubes [including Precautions for Satisfactory Operation].—C. E. Haller. (*Proc. I.R.E.*, Jan. 1942, Vol. 30, No. 1, pp. 20–26.) A summary was referred to in 1060 of April.

1683. On Space-Charge Effects in Velocity-Modulated Electron Beams.—Fuchs & Kompfner. (*See* 1643.)

1684. The Effect of Space Charge on the Potential and Electron Paths of Electron Beams [More Important Results of Analyses collected from Literature and presented in Curves & Nomograms for Practical Application: Diodes, Tetrodes, Long Flat Beam, Cylindrical Beam].—D. P. R. Petrie. (*Elec. Communication*, No. 2, Vol. 20, 1941, pp. 100–111.)

1685. On the Theory of Electron-Plasma Oscillations.—R. Seeliger. (*Zeitschr. f. Phys.*, 1st Feb. 1942, Vol. 118, No. 9/10, pp. 618–623.)

Author's summary:—"It is shown how the Langmuir oscillation-equation for the plasma electrons can be arrived at by a combination of the potential equation and the equation of motion either with the continuity equation of electron flow ["hydrodynamic" treatment: $\partial n/\partial t + \partial(nv)/\partial x = 0$] or with the equation for the total current made up of the displacement and convection currents ["electrical" treatment: $J = (1/4\pi) . \partial E/\partial t + env$]: how these two ways of treating the problem are interconnected: and that they are completely equivalent." The difference between the problem here considered and that dealt with by Schumann (2685 of 1941), which also involves the Langmuir frequency $\sqrt{4\pi e^2 n_0/m}$, is pointed out in §4: this section also calls attention to the fact that the transit-time theory of electron flow can, in an analogous way, be developed either on hydrodynamic or on electrical lines: an example of the former is provided by Benham's work (1928 Abstracts, p. 288), of the latter by Müller's papers, 1933 Abstracts, pp. 443–444, and 502 of 1936.

1686. On the Dielectric Constants of Ionised Gases at Medium Radio-Frequency.—Khastgir & Choudhury. (*See* 1599.)

1687. Theory of the Variation of the Resistance of a Thermionic Valve with Frequency.—S. R. Khastgir. (*Indian Journ. of Phys.*, Oct. 1941, Vol. 15, Part 5, pp. 317–321.)

For a shortened version see *Sci. & Culture*, May

1941, Vol. 6, No. 11, pp. 671–672. Mitra & Sil developed a theory of this variation (1932 Abstracts, p. 463) and showed that their experimental results were entirely at variance with Hartshorn's theory (1931 Abstracts, p. 618). Rao (93 of 1941) extended the frequencies downwards and found that the decrease in resistance with decreasing frequency, found by Mitra & Sil, changed to a gradual increase at the lower frequencies now used. "This latter result, which has also been recently confirmed by a different method [*see* Basak, 1688, below], cannot be explained according to Mitra & Sil's theory," according to which the resistance should be constant below a certain limiting frequency. The present writer accepts their fundamental ideas regarding the conductivity due to convection current, but takes into account that arising from the displacement currents. He finds that σ_d, the specific conductivity due to these currents, is equal to $\epsilon\omega/4\pi$. "It was shown by Khastgir & Choudhury (92 of 1941: for an extension *see* 1599, above) that the value of $(1 - \epsilon)$ varied inversely as the square of frequency. Even if ϵ were regarded as constant, σ_d would steadily increase with the increase of frequency," while the conductivity due to the convection current, as soon as the frequency exceeds the limiting value defined by eqn. 3, would no longer remain constant but would begin to decrease steadily with further increase of frequency. "The experimental results on the conductivity of a valve for a wide range of frequencies can therefore be explained."

Rao's tests on a Telefunken valve gave the turning point at a wavelength of about 180 m, much longer than the value of 30–45 m to be expected from eqn. 3. "The equation $e\phi/300 = \frac{1}{2}mu_0^2$, from which eqn. 3 is derived, is however based on classical ideas. The results should be reviewed in the light of modern views of electron emission from metals."

1688. On the High-Frequency Conductivity and Effective Dielectric Constant of Electronic Medium in a High-Vacuum Thermionic Valve [in the Medium Frequency Band].—R. G. Basak. (*Indian Journ. of Phys.*, Oct. 1941, Vol. 15, Part 5, pp. 343–358.)

An investigation of the anode/screen-grid space in a Philips B442 valve, with a view to estimating the merits of the theories put forward by Benner (1930 Abstracts, p. 152), Hollmann & Thoma ("inversion" theory: 3840 of 1938), and Mitra & Sil (1932 Abstracts, p. 463). The first set of measurements, at two different frequencies, gave a linear relation between conductivity and electron concentration: this would be expected from any of the theories. The second set gave a conductivity, for a fixed thermionic current, increasing as the frequency was increased over the range in question, 512 kc/s to 1000 kc/s (agreeing with Rao's results: *see* Khastgir, 1687, above). The third set (Fig. 5), with thermionic current maintained constant while the anode voltage was varied, showed a very rapid increase in conductivity, for a fixed frequency, with increasing time of stay of the electrons. The first result, though qualitatively conforming with either Benner's or Hollmann & Thoma's theory, gives by either theory quite unsuitable values for the electron concentration. The second result is contrary to Benner's theory and when combined with Rao's results is contrary also to Hollmann & Thoma's theory. The third result showed an observed increase in conductivity which was too rapid for either theory. Khastgir's theory (*loc. cit.*) is therefore adopted.

As regards the effective dielectric constant, previous experiments have shown that both Benner's and Hollmann & Thoma's expressions are untenable (456 of 1940 and 92 of 1941). In these papers a multiplying factor $\mu = (A/\lambda) \,.\, f(T)$ was introduced into the Lorentz formula for the dielectric constant of a frictionless electronic medium, to allow for the effect of the time of stay of the electrons in the interelectrode space: it was shown that μ was independent of A/λ and depended only on the time of transit. The experiments now described were to find the nature of this dependence. It was found that until the anode voltage was raised above the point where secondary emission occurred, the effective dielectric constant increased as the voltage increased: that is, it decreased as the time of stay was increased. It is therefore concluded that μ, in the modified Lorentz formula $\epsilon = 1 - 4\pi(N\mu)e^2/m\omega^2$, must increase with the increase of the transit time T.

1689. Optimum Conditions for Maximum Power in Class A Amplifiers.—Nottingham. (*See* 1634.)

1690. The Operation of Frequency Converters and Mixers for Superheterodyne Reception [General Analysis of Operation common to All Types (including Fluctuation Noise): Comparison of Advantages & Disadvantages of Three Conversion Methods: Improved Constructions for Mixers designed for Outer-Grid Injection: etc.].—E. W. Herold. (*Proc. I.R.E.*, Feb. 1942, Vol. 30, No. 2, pp. 84–102.)

1691. The Choice of Valves for Modern Technical Amplifiers [for Studio Purposes, etc: Doubtful Validity, nowadays, of the Idea that only "Technical" Valves, with Closer Tolerances than Usual Broadcast-Receiver Valves, are Permissible: Comparison of AC100 & Ca "Technical" Types with the E Series, such as the EF12, of Broadcast-Receiver Valves].—W. Schlechtweg. (*E.N.T.*, Oct. 1941, Vol. 18, No. 10, pp. 219–221.)

1692. Amplification by Secondary-Electron Emission in Static Multipliers.—H. Schnitger. (*E.T.Z.*, 29th Jan. 1942, Vol. 63, No. 3/4, pp. 41–46.)

The silver-oxide/caesium films almost exclusively used to-day in photomultipliers have the advantage of good secondary emission (for 400 v primary voltage, nine secondaries for each primary), but they are quickly destroyed by temperatures around 200° C and are therefore unsuitable for multipliers with anything approaching a large output. The search for better secondary-emission layers has led, so far, to the development of layers of magnesium oxide (4456 [and 549] of 1939: 2718 of 1941) and of oxidised beryllium alloys (reference "2," and 2135 & 2717 of 1941), both of which will stand 500°C and over. The usefulness of the ratio u/p for comparing the merits of such layers is explained and illustrated by a comparison of the magnesium-oxide and silver-oxide/caesium layers: *see* long abstract, 451 of February.

Section 2 deals with different types of multiplier from the electron-optical viewpoint: special attention is given to the Weiss "net" multiplier, and to the high efficiency (nearly 100%) of the Slepian type with an auxiliary magnetic field (Fig. 3d). The limiting of the permissible output-current strength, both by space charge and thermal loading, is discussed in section 3. Section 4 deals with background noise: the additional component due to secondary emission can be calculated approximately by the Schottky formula (the paper by Zworykin & others, 2185 of 1936, is here quoted): the question of how much better, as regards noise, a photomultiplier is than a photocell/amplifier combination, is considered by calculating the smallest permissible photocurrent I_0 for the two cases under similar conditions, for a given height H of the signals above the background-noise level and a given modulation depth M: the ratio E of these currents is found to be 3800 M/H, which is independent of the band width and which gives as a typical value, for $H = 8$ and $M = 0.4$, a sensitivity improvement of about 200 times on using the multiplier. The question as to the optimum number of stages is answered by the fact that in the most favourable case the additional noise due to the coupling elements in the anode circuit is reduced to practically zero: this occurs when the multiplication reaches about $5E$, that is, 1000 (Preisach, 2864 of 1939): so far as noise is concerned a further increase in stages would improve matters very little. In caesium-activated cathodes the dark current I_D at room temperatures (which does not as a rule interfere with a photocell/amplifier combination) reduces the smallest permissible photocurrent I_0 for a multiplier, and thus reduces the improvement-ratio E: the new ratio E' is given by $E' = E/(0.5 + 0.5\sqrt{1 - 4I_D/I_0})$, which when the dark current is taken as equal to the smallest permissible cathode current gives an improvement-ratio of only about 124 instead of 200.

Section 5 deals first with multipliers designed specially for television, beginning with the "net" type and "zig-zag" types, and passing then to the magnetic type with specially designed permanent magnets and soft-iron poles, having the electrodes deposited on the glass walls (Figs. 7 & 8): the complete magnet for a 10-stage multiplier, with "Magnetoflex" iron-nickel-copper alloy, weighs only 270 gms. The magnet body serves for various auxiliary purposes: thus it carries inside the potentiometer for all except the last stages. A 10-stage multiplier of this type gives a "characteristic voltage" (*see* 451 of February) of only 65 V per neper; the max. output current, limited by space-charge and thermal considerations, is about 1 mA. The superior stability against supply fluctuations possessed by the permanent-magnet multiplier, compared with the electrostatic type, is pointed out and illustrated by the curves of Fig. 10: for a 1% voltage fluctuation the multiplying factor alters by only 0.8%, compared with 3.4% with a magnet-less type. For large fluctuations (usually avoided easily) conditions are better for the electrostatic type, but the stability of the magnetic type can be improved by making the permanent magnet provide, say, only 64% of the total field, the remainder being furnished by a field winding supplied from the electrode-voltage source. A 1% fluctuation then causes a factor variation of only 0.1% (curve 3 of Fig. 10). Finally it is mentioned that for many purposes it is desirable to make the internal resistance R_i as high as possible in comparison with the fixed external resistance, to avoid the distortion due to variations of R_i with the light flux changes: this high internal resistance is obtained by a separate leading-out of the field electrode in front of the last s.e. electrode, instead of a direct connection to the anode: it can thus be maintained at a constant potential.

Section 6 deals with grid-controlled multipliers for the amplification of wide frequency-bands (2334 of 1938: 1466 of 1939 [use of the initial-current region]: and 2415 of 1941 [various methods, including the initial-current region]). This use of the initial-current region is discussed: it has great advantages as regards steep slope, but it is bad from the point of view of noise. It is concluded that the input current of a multiplier should not be reduced below the point where the curve of relative slope (S/I curve) lies in the space-charge region. The 3-stage grid-controlled multiplier of Fig. 12, on these lines, has a slope of 30 mA/V with an output current of 10 mA and a 12 pF valve-capacitance, so that the ratio S/C, of great importance for wide-band amplification, is 2.5, which is a great improvement on the 0.7 normally obtained with amplifier valves. The equivalent noise-resistance is 5 kilohms.

1693. THE EFFECT OF THE ANGLE OF EJECTION ON THE ENERGY DISTRIBUTION OF SECONDARY ELECTRONS.—Yu. M. Kushnir & M. I. Frumin. (*Journ. of Tech. Phys* [in Russian], No. 4, Vol. 11, 1941, pp. 317–322.)

Experiments made with Mo and Ag layers are described and experimental curves shown. The results obtained are discussed, and the main conclusion reached is that with an increase in the angle of ejection (measured from the direction normal to the surface) the maximum for the energy distribution of secondary electrons moves towards faster electrons (Figs. 3–6). It has also been observed that the curves showing the distributions of electrons for varying angles of ejection have a number of well-defined maxima and minima. It is suggested that this phenomenon is due to the diffraction effect.

1694. THE CRYSTALLOGRAPHIC STRUCTURE OF ALKALINE-EARTH OXIDE MIXTURES: INVESTIGATIONS ON OXIDE CATHODES WITH THE HELP OF RÖNTGEN RAYS AND ELECTRON BEAMS.—H. Huber & S. Wagener. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 23, 1942, pp. 1–12.)

In his 1941 Berlin Dissertation Huber showed that the thermionic emission from oxide cathodes composed of various binary mixtures BaO-SrO, BaO-CaO, and SrO-CaO displayed characteristic differences between the BaO-SrO system and the

SrO-CaO system on the one hand and the BaO-CaO system on the other. Since Benjamin & Rooksby have already reported (1933 Abstracts, p. 569) that the emission current from BaO-SrO cathodes is favourably affected by the formation of mixed crystals, the crystallographic structure of the other mixed-oxide cathodes ought also to be important with regard to their emitting properties. The present investigation of the structure of these cathodes should therefore contribute to our knowledge of the dependence of emission on the composition of such cathodes.

Authors' summary :—" The crystallographic structure of oxide cathodes consisting of binary mixtures of the alkaline-earth oxides BaO, SrO, and CaO is examined. The carbonate mixtures used for the preparation of the oxide mixtures, and obtained by a common precipitation [from nitrate solutions], are shown by Debye-Scherrer photographs to be composed entirely of mixed crystals. It is found by similar means that in accordance with Grimm's mixing rules [reference " 14 "] the BaO-SrO and SrO-CaO mixtures are composed of mixed crystals, while the BaO-CaO mixtures consist of a microcrystalline medley [a mixed-crystal formation being possible, according to Grimm, only when the difference in the lattice constants is not more than 11%].

" Electron-diffraction photographs, taken with the Seemann apparatus, showed at the surface of all the oxide mixtures the presence of a layer of the less easily vaporisable component [the other component having been evaporated out of the layers near the surface by the usual process of oxide-cathode formation]. The layer thickness is estimated at between 300 and 2000 atomic layers. The significance of the results for the emitting properties of mixed-oxide cathodes is discussed " : the fact that the conditions at the surface of the cathodes after the activating process are similar indicates that with the BaO-SrO system, as with the other systems, the surface alters little in structure or composition over a wide range of mixtures. Consequently the surface work function, governing the electron emergence, must remain approximately constant over this range, so that all variations of emission within this range must be attributed to the influence of the deeper-lying oxide layers, *i.e.* chiefly to the semiconductor properties. This conclusion is strengthened by the fact that the mixed-crystal systems (BaO-SrO and SrO-CaO) show fundamentally similar emission characteristics plotted against composition, in contrast to the BaO-CaO system with its microcrystalline mixture of components. This indicates that the semiconductor properties of mixed-oxide cathodes are considerably changed by the formation of mixed crystals, in that the " Ablösearbeit " of the electrons in the interior of the crystals is diminished [van Geel, 1931 Abstracts, p. 513, uses the term " Ablösearbeit " to denote ΔW, where W is the Sommerfeld internal work function]. " At present no direct experimental material is available concerning such influence, so that nothing definite can be said about the mechanism."

1695. The Magnetic Induction Field of Air-Core Coils and Its Application to High-Frequency Heating in Valve Manufacture.—C. B. Kirkpatrick. (*A.W.A. Tech. Review*, Dec. 1941, Vol. 5, No. 6, pp. 292–250.)

Author's summary :—" Expressions are derived for the axial components of the magnetic induction field of both three-dimensional and two-dimensional coils : in particular the Helix, the Spirals $r = k\theta$ and $r = r_0 e^{k\theta}$, and the simple Circular Coil are investigated. Efficient heating by a h.f. induction field, and the design of heater coils such as those use in valve manufacture, are discussed in some detail."

1696. Adsorption Properties of Metallic Zirconium for Gases, and Its Applications to Electron Tubes.—S. Hukagawa & J. Nambo. (*Electrotech. Journ.* [Tokyo], Feb. 1941, Vol. 5, No. 2, pp. 27–30.)

The action " is extremely strong against all harmful gases when the Zr is at 400° to 600°C . . . transmitting tubes of a much smaller size than heretofore can be made . . . Zr treatment was also given to the grids, which was effective in diminishing secondary electron emission . . . average life of some types of tubes was doubled." Can also be used to purify the gases (neon, etc.) used in the manufacture of discharge tubes, etc.

DIRECTIONAL WIRELESS

1697. Radiating System for 75-Megacycle Cone-of-Silence Marker [for Canadian Airways : with Sharper Vertical Beam and Smaller Orientation Effect].—E. A. Laport & J. B. Knox. (*Proc. I.R.E.*, Jan. 1942, Vol. 30, No. 1, pp. 26-29.)

1698. An Ultra-High-Frequency Two-Course Radio Range with Sector Identification.—A. Alford & A. G. Kandoian. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 664 : summary only.)

1699. A Wide-Range, Linear, Unambiguous, Direct-Reading Phasemeter [delivering a Direct Current proportional to Phase Angle].—Shepherd. (*See* 1747.)

1700. Fundamental Considerations on the Electrical and Acoustical Means for Aircraft Navigation in Foggy Weather.—W. Hahnemann. (*Bull. Assoc. suisse des Élec.*, 28th Feb. 1941, Vol. 32, No. 4, pp. 67–68 : summary, in German, from *Lorenz-Berichte*, No. 3/4, 1939, p. 73 onwards.)

Leading to a table showing the relative applicability of various waves, electromagnetic and acoustic, for various types of navigation aid, namely long-distance, normal-distance, and close horizontal d.f. ; vertical location (altitude determination) for great and small heights ; precision guiding for landing or taking-off ; collision prevention (obstacles) and collision prevention (other aircraft). It is suggested that the cosmic rays (" wavelengths 10^{-11} to 11^{-13} cm ") will eventually be useful for measuring great altitudes, where the barometer fails. Millimetric waves are considered to present few possibilities, because like infra-red rays their advantage over luminous rays is too small to make the added complications worth while, and moreover they do not come back from the ground: they are, however, easy to concentrate. So are the centimetric waves, and these, recent investigations have shown, have quite large ranges, up to 50 km: when transmitting and receiving apparatus has been improved they should offer some possibilities. Decimetric waves are suitable for most of the duties in question, except when the distances exceed the optical range: they are well reflected from the ground. Metric waves have ranges rather greater than the optical: those over 6 m have much greater ranges, thanks to reflection at the ionosphere, and are very suitable for all navigation problems, except (because they are too long to concentrate with small reflectors) collision prevention.

1701. Direction Finding at Medium-High Frequencies and the United Air Lines Ground-Station Direction Finder.—P. C. Sandretto & E. P. Buckthal. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, p. 604: summary.)

1702. Simultaneous Aural and Panoramic Reception [Adaptor permitting Uninterrupted Visual Observation of Relatively Wide Band above & below Station listened to: Many Applications].—M. Wallace. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 667: summary only.) For previous work on panoramic reception *see* 1088 of 1941 and back reference.

1703. The Automatic Tuning of Amplifying Stages [for Distance-Determination Technique, etc.].—V. I. Yuzvinski. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 11, 1941, pp. 456–459.)

In a number of cases, as for example in determining distances by the Mandelstam-Papalexi method (*see* 836 & 3103 of 1938, 3176 of 1939, and 622/627 of March and back references), the frequency of the received e.m.f. may vary within wide limits. At the same time it is important that the amplification factor of the receiving amplifier, and the phase displacement, should be kept constant over the whole frequency range. It is pointed out that the use of band-pass filters is not satisfactory since this does not ensure the constancy of the phase displacements. It is therefore necessary to use amplifiers which automatically adjust their natural frequency to the frequency of the incoming e.m.f. Amplifiers with regenerative feedback satisfy this requirement, but their gain does not remain constant. A circuit is therefore proposed (Fig. 2) using combined negative and positive feedback. The theory of the circuit is discussed and results of experiments are given. It appears that the variation of the gain of this amplifier is of the order of 4–8% for a frequency change of 8%, which is quite permissible for practical purposes. For an English version see *Journ. of Phys.* [of USSR], No. 1/2, Vol. 4, 1941, pp. 147–150.

ACOUSTICS AND AUDIO-FREQUENCIES

1704. A New "Double-Layer" Condenser Microphone for the Transmission of Speech [to give particularly Good Intelligibility (for Railway Platform & Similar Control Purposes) with Imperviousness to Shock, Moisture, High Temperatures, etc.].—M. Gosewinkel & H. Bauer. (*E.T.Z.*, 29th Jan. 1942, Vol. 63, No. 3/4, p. 50: summary only.)

To obtain the best possible intelligibility the microphone and its associated equipment is designed to emphasise the higher frequencies, at and on either side of 4000 c/s: the microphone alone gives good transmission between about 250 c/s and 6000 c/s but its transformer reduces the output of the lower frequencies. The large diameter and small air gap enables the capacitance to the large compared with the cable capacitance, so that the pre-amplifier stage need no longer be combined with the microphone but may be connected by a 200 m cable (*cf.* Reichardt, 1083 of April). The term "double-layer" is due to the fact that the dielectric is partly air and partly a solid synthetic material: the solid dielectric is combined with the vibrating diaphragm, by making the moving electrode in the form of a metallic layer deposited on the diaphragm. Between the two electrodes there is an interposing layer with seven circular apertures: this divides the whole into seven small condenser microphones and gives the diaphragm high natural frequencies without the need for it to be tightly stretched. The fixed electrode is provided with holes to allow the passage of air as the diaphragm vibrates. For an illustrated summary see *Alta Frequenza*, Feb. 1942, Vol. 11, No. 2, pp. 99–101.

1705. The "Vivavox" Intercommunication System.—(*Bull. Assoc. suisse des Élec.*, 19th Dec. 1941, Vol. 32, No. 25, pp. 726–728.)

1706. Transverse Vibrations of Triangular Membranes.—B. R. Seth. (*Sci. Abstracts*, Sec. A, Dec. 1941, Vol. 44, No. 528, p. 394.)

1707. A Discussion of Several Factors contributing to Good Recording.—R. A. Lynn. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 331: short summary only.)

1708. Development Lines of Sound-Lamp Technique [Survey of Patents for Lamps for Sound Tracks of Films: Their Particular Requirements, fulfilled by Special Design or Compensating Circuits].—J. Baltzer. (*E.T.Z.*, 9th Jan. 1941, Vol. 62, No. 2, pp. 31–33.)

1709. Distortion Tests by the Intermodulation Method [" for Commercial Testing of Audio, Radio, & General Sound-Recording Equipment "].—J. K. Hilliard. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, pp. 614–620.)

"As the intermodulation test is approximately four times as sensitive as the harmonic-analysis method, it approaches the sensitivity of the ear in detecting intermodulation effects, and it is a very valuable tool with which to measure distortion."

1710. A Note-Frequency Spectrometer and Note-Frequency Spectrograph with Inertialess Commutator. — P. Vetterlein. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 23, 1942, pp. 17–24.)

Freystedt's "audio-frequency spectrometer" (1474 of 1936 [*see* also 3943 of 1935]) with its cathode-ray-tube indication has become indispensable for the investigation of speech, but it involves the use of a motor driving two extremely carefully designed and constructed commutators. If only for the elimination of the noise, the substitution of an electronic arrangement would be a great advantage. This has been done in the equipment here described, and has brought with it additional simplifications.

The writer describes his search for a satisfactory electronic commutator. He refers to the survey of existing devices contained in Raabe's paper on multiplex transmission (859 of 1940), and also to Kramolin's suggested arrangement of a c.r. tube with rotating ray (no reference is given, but for Russian work on such devices *see*, for instance, 1642 & 4255 of 1937 and 4524 of 1940: also *cf.* 2626 of 1938). This latter scheme has its advantages, but is too complicated for a sound analyser. On the other hand the circuit adopted by Raabe is simple in itself but requires a pulse generator which, for a large number of analysing channels, would become too elaborate and unreliable.

The writer therefore directed his thoughts on the following lines: the processes of the analyser require that a succession of d.c. voltages (*i.e.* the sound components after passing through their respective filters and after rectification and storage in their respective storage condensers) should be connected in turn; but, simultaneously, that the cathode ray should be deflected along its time axis in synchronism with this series of switchings. The obvious thing to do, therefore, is to base the whole process on the time-axis deflection and to devise an arrangement which connects up each channel in turn according to the deflecting voltage obtaining at any particular moment, which measures the voltage belonging to that channel, and which makes it visible. The first realisation of such an arrangement was based on the use of dry-plate rectifiers, each channel having its own control circuit shown in Fig. 2; a three-channel system (Fig. 3) was built but was found to have several disadvantages, not the least being that each channel required four rectifiers and three transformers.

The final solution was found to lie in replacement of the control circuit of Fig. 2 by a hexode circuit in a controllable saturation connection (Fig. 4). Here the electrons emerging from the cathode and accelerated to the grid G_2 pass through this and traverse at constant speed the field-free space between G_2 and G_3 (which is at the same potential as G_2), and reach the anode A (also at the same potential) only if the retarding grid G_4 is at a potential lying between that of the cathode and that of the anode: if G_4 is more negative than the cathode, the electron velocity will not be great enough to run counter to the field of G_4, and the electrons will be deflected back to G_3: but if G_4 is even slightly positive to the cathode, all electrons not actually striking G_3 will reach the anode. Thus while G_4 is negative I_a will remain zero, rising almost vertically to a definite saturation value when G_4 is at zero with respect to the cathode (full-line curves of Fig. 5: *a*, *b* and *c* show how the value of the saturation current depends on the voltage on the first grid, G_1). The lower and upper bends are extremely sharp and the current, outside the critical region of G_4 potential, extremely constant. A three-channel commutator made up from three such valves is seen in Fig. 6: all the cathodes, anodes, and G_2, G_3 grids are interconnected, and the retarding grids G_4 are connected also, but with the interposition of small potential sources, batteries or potential-dividers. The varying control voltage U_s is applied between the first G_4 and the cathodes, and the total anode current from the three valves, as a function of this voltage, takes the "flight of steps" form shown in the oscillogram of Fig. 7, the height of the steps being adjustable by the bias on G_1. Finally a differentiating circuit (with a nickel-iron-cored inductance) is introduced into the common anode lead, to give a voltage peak only when the anode current changes as it mounts a step (*see* dI_a/dU_s curve of Fig. 8). The height of these peaks depends (apart from the change of U_s with time) only on the bias on the first grid of the valve concerned. Each d.c. voltage to be switched on (that is, in the spectrometer, each storage condenser) is connected to the first grid of the valve belonging to its channel, and the voltage peaks are amplified, rectified, and applied to the deflecting plates of the c.r. tube. It is from the time-base voltage of this tube that a fraction is tapped off to provide the synchronous U_s. This voltage can be supplied by the mains, which helps to make the whole apparatus extremely simple compared with the Freystedt equipment.

Fig. 10 shows a ten-channel commutator circuit with its amplifier and c.r. tube. In addition to the latter, used for visual observation, a double-loop oscillograph can be connected to the output: one loop can record the complete sound curve, while the second gives another trace, above this, which at intervals depending on the commutating speed (1/25th second for 50 c/s mains) reproduces the component-tone spectrum. The whole equipment is then known as a note-frequency spectrograph.

1711. PROPAGATION OF SOUND THROUGH THE ATMOSPHERE.—B. Haurwitz. (*Journ. Roy. Aeron. Soc.*, April 1942, Vol. 46, No. 376, pp. 125–126: summary only.)

1712. ON THE THEORY OF CYLINDRICAL AND SPHERICAL WAVES IN FRICTIONLESS GASES AND LIQUIDS.—H. Marx. (*Ann. der Phys.*, 6th Feb. 1942, Vol. 41, No. 1, pp. 61–88.) On physical implications of some of Bechert's results (2361 of 1941 and 20 of January.)

1713. THE ACOUSTICAL SOCIETY AND NOISE ABATEMENT, *and* BIBLIOGRAPHY ON NOISE.—P. E. Sabine. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 207–209: p. 210.)

1714. REPORT OF ACTIVITIES OF THE NATIONAL NOISE ABATEMENT COUNCIL, *and* CITY NOISE.—G. P. Little & F. E. McGee: S. W. Wynne. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 211–213: pp. 214–216.)

1715. HISTORY OF NOISE ABATEMENT IN NEW YORK CITY, *and* GREATER CHICAGO NOISE SURVEY.—E. H. Peabody: H. A. Leedy. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, p. 332: p. 332: summaries only.)

1716. The Design of the Cells of an Acoustic Filter when the Dimensions of the Cells are Not Small in comparison with the Wavelength.—B. K. Shapiro. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 11, 1941, pp. 460–473.)

A theoretical discussion of sound absorption by a series of expansion chambers (cells) connected by pipes, as used with internal combustion engines, ventilators, etc. A cell of dimensions comparable with the length of the incoming sound wave is considered and its constants and sound-absorption characteristic are determined. An experimental verification of the theory has been made.

1717. An Experiment on Middle-Ear Deafness [leading to Removal of Phase-Reversal Difficulty in Explanation of Otosclerotic Deafness], *and* The Temporary Deafness of Birds [Cochlear Response reduced when Mouth is Opened].—K. Lowy: C. W. Bray & W. R. Thurlow. (*Journ. Acous. Soc. Am.*, Jan. 1942, Vol. 13, No. 3, pp. 335: summary only.)

1718. The Physiology of the Human Ear treated by the Method of Reciprocal Representation.—de Gruyter. (*See* 1629.)

1719. The New "Additional" [Booster] Repeater Type V42 of the State Broadcasting Company [for Use in Each Branch Line from Main Amplifier: Special Requirements: Great Economy in Size & Material, compared with the Type V22, by Negative Feedback: Use of Type EF12 Valve].—J. Peters. (*E.N.T.*, Oct. 1941, Vol. 18, No. 10, pp. 222–226.) *See* also 1691, above.

1720. Viewpoints for the Development and Manufacture of Telephone Line Amplifiers [Intermediate and Terminal Repeaters: Requirements for Satisfactory Mass Production: Statistical Investigation: New Repeater using Screen-Grid Valves in place of the Ba Triode: etc.].—M. Kluge. (*E.N.T.*, Nov. 1941, Vol. 18, No. 11, pp. 252–263.)

1721. Sensitive Flames: III [Hydrodynamic Processes: Flames as Amplifiers of Motion: Electrical Excitation: etc.].—H. Zickendraht. (*Sci. Abstracts*, Sec. A, Dec. 1941, Vol. 44, No. 528, p. 394.) For previous work *see* 1934 Abstracts, p. 567, r-h column.

1722. Theoretical and Experimental Study of Supersonic Gaseous Jets.—D. Riabouchinsky. (*Comptes Rendus* [Paris], 29th Sept. 1941, Vol. 213, No. 13, pp. 424–428.)

1723. Preparation of Quartz Ultrasonic Oscillators [for Use in Investigation of "Certain Irrigation Problems"].—R. R. Bajpai & V. I. Vaidhianathan. (*Sci. Abstracts*, Sec. A, Dec. 1941, Vol. 44, No. 528, p. 395.)

PHOTOTELEGRAPHY AND TELEVISION

1724. Television—The Scanning Process.—P. Mertz. (*Bell Tel. S. Tech. Pub.*, Monograph B-1324, 24 pp.) Dealt with in 1103 of April, where the author's name was spelled wrongly.

1725. Automatic Radio Relay Systems for Frequencies above 500 Megacycles [with Particular Reference to Successful R.C.A. Experimental Transmission of Television Signals through Several Unattended Repeaters without Demodulation & Remodulation: etc.].—J. Ernest Smith. (*Proc I.R.E.* Dec. 1941, Vol. 29, No. 12, p. 666: summary only.)

1726. A Simple Television Demonstration System [150-Line Equipment using the Small Iconoscope: Total Cost less than That of Commercial-Type Iconoscope alone].—J. B. Sherman. (*Proc. I.R.E.*, Jan. 1942, Vol. 30, No. 1, pp. 8–15.) For this small iconoscope *see* 3090 of 1940.

1727. Orthicon Portable Television Equipment [particularly for Adverse Light Conditions: Novel Features, including Forced Air Cooling of Power Transformer and Regulator & Rectifier Valves].—M. A. Trainer. (*Proc. I.R.E.*, Jan. 1942, Vol. 30, No. 1, pp. 15–19.) A summary was referred to in 1108 of April.

1728. Mobile Television Equipment [Camera Equipment for Studio & Outdoor Use: Mobile Camera-Control Dolly, Electronic View-Finding System, Synchronising Equipment, etc.].—R. L. Campbell & others. (*Proc. I.R.E.*, Jan. 1942, Vol. 30, No. 1, pp. 1–7.) From the DuMont Laboratories.

1729. Motion-Picture Lens with Vibrated Auxiliary Lens maintaining "Uniform Soft Focus" from Four Feet to Infinity.—(*Sci. News Letter*, 28th Feb. 1942, Vol. 41, No. 9, p. 143: paragraph only.) *Cf.* 2758 of 1941.

1730. Amplification by Secondary-Electron Emission in Static Multipliers.—Schnitger. (*See* 1692.)

1731. Factors governing Performance of Electron Guns in Television Cathode-Ray Tubes [Derivation of Formula for Upper Limit of Useful Beam Current].—R. R. Law. (*Proc. I.R.E.*, Feb. 1942, Vol. 30, No. 2, pp. 103–105.)

"For any given structure, the ratio of the measured beam current to the computed limiting value affords a figure of merit describing the performance of the gun. This ratio is ordinarily about one-tenth (Jacob, 3625 of 1939), but by minimising the effects of space charge in the first-crossover-forming region, Pierce (4275 of 1940) has obtained current densities of over one half the limiting value."

1732. Image Errors occurring in the Deflection of a Cathode-Ray Beam in Two Crossed Deflecting Fields.—G. Wendt. (*Zeitschr. f. Phys.*, 1st Feb. 1942, Vol. 118, No. 9/10, pp. 593–617.)

From the Telefunken television laboratories. The deflection equations and deflection errors for a *single* deflecting organ with double symmetry *i.e.* having two planes of symmetry at right angles to each other and passing through the tube axis) are already known: references are given to Glaser, 1577 of 1939, and to the present writer, 3225 of 1939. In c.r. oscillographs, however, and in television pick-up cameras and receivers, and c.r. commutators, two fields are always employed, deflecting in directions at right angles to each other. There occur then, in addition to the deflection errors characteristic of each field, further errors due to the interaction of the two fields. These are not, fundamentally, of a new type, but they must be taken into account if an error-free television raster or cathode-ray oscillogram is to be obtained. "For this reason the deflection laws will be derived in the following pages for a system composed of two mutually perpendicular deflecting fields, and the error-coefficients calculated. Finally, the form of the error for a central beam (*i.e.* one incident in the direction of the axis of the system) will be discussed in detail. It is usually possible in special applications to replace the more or less complicated expressions for the error-coefficients by simplified and clearer formulae. For the example of a system composed of two *similar* magnetic deflecting fields with coincident principal planes, such simplifications are given, and with their assistance an investigation is carried out on the avoidability of the errors." The two deflecting systems are assumed to be either both purely electrostatic or both purely magnetic: "the use of a combined field is generally rejected on account of the elaborateness of the circuits." The independent and just published work of Picht & Himpan (3091 of 1941) is referred to in a footnote: it deals with the deflection errors of electrostatic fields only, deflecting in two directions and extending indefinitely in one direction, and the treatment of the series development and of the error calculation represents a different viewpoint.

It is shown that the errors occurring are (i) distortion (Fig. 4: deformation of the whole image, not of the spot: independent of the ray cross section, and taking the form of "scale distortion," diagrams b–e: of coordinate curvature, either of "pincushion" or "barrel" type, diagrams f–k: or more generally a combination of scale and coordinate distortions, diagrams l & m): (ii) astigmatism, isotropic and anisotropic (increasing linearly with the ray radius at the deflecting field): and (iii) coma, increasing as the square of the ray radius. These last two types of error affect the form of the spot only, not that of the raster or image. The investigation, mentioned above, of the possibility of eliminating these errors in a special case is carried out on pp. 613–617. Coma is the only type that can be eliminated completely; for the others a compromise must be arrived at.

1733. THE MOST FAVOURABLE FORM OF SO-CALLED "MAT" COILS FOR MAGNETIC DEFLECTION IN CATHODE-RAY TUBES.—H. Scholz. (*E.N.T.*, Nov. 1941, Vol. 18, No. 11, pp. 239–246.)

The design of deflecting coils involves two problems, the determination of the number of turns, based on the current available from the external circuit, and the obtaining of a homogeneous magnetic field so that image distortion may be avoided. "On the first problem several papers have already appeared [Bähring, 3628 of 1939: Günther, 219 of 1940: *Philips Miniwatt Monatshefte*, 1939, Nos. 66 & 73], while on the latter only a single paper exists [the Philips journal, No. 69, 1939, is again cited], which by testing various forms of 'mat' windings and obtaining the lines of force by means of iron filings seeks to obtain the best, most uniform field." Many forms of coil exist (for type names a paper in *Telefunken-Röhre*, March 1941, No. 19/20, is referred to) but they all have one point in common: they are wound as "concentratedly" as possible, each new winding being arranged as like as possible to the last, so that the resulting coil can be treated theoretically as a single conductor of the appropriate shape.

The present paper deals with a type of winding in which the individual turns are not "concentrated" but deliberately wound side by side as in a door-mat, the "mat" being curved so as to fit round part of the tube neck. The object of the paper is to determine how much of the neck should be left uncovered by a pair of "mats" in order that the field may be most homogeneous. It is concluded that the best design of deflecting coil is a pair of "mats" having an internal aperture angle of 2 × 28.5° = 57°: that is, two uncovered arcs of neck are left, each subtending 57° at the axis of the tube.

1734. THE DISPLACEMENT, IN TIME, OF SERIES OF PULSES [Synchronising Signals, for the Correct Mixing of Pick-Ups at Various Distances from the Transmitter].—K. Brückersteinkuhl. (*E.T.Z.*, 12th Feb. 1942, Vol. 63, No. 5/6, pp. 75–76: summary, from *Mitteil. Fernseh-A.G.*, Vol. 2, 1941, p. 46 onwards.)

The synchronising signals sent out from the central station reach the various pick-up points with different delays, and the image signals sent back to the central station also suffer delays depending on the length of the cable. The transit time in a television cable about 25 km long amounts to 90.7 μs, corresponding to the time for tracing one line of a 441-line image: this is taken as the standard. Since no image signals, but only the synchronising signals, have to be delayed in order to carry out the equalisation, the necessary circuits are comparatively simple, but if these signals had to be transmitted with fidelity of form about 1000 choke sections would be required, which would mean considerable attenuation from eddy-current losses in the windings and iron cores. Luckily such fidelity is not necessary, and a 90.7 μs delay can be obtained with only 100 sections: the distorted signal emerging from the network is reconverted into rectangular form by an amplifier. The arrangement is seen in Fig. 4.

1735. A METHOD OF LIGHT MODULATION BASED ON THE USE OF A QUARTZ CRYSTAL AT HIGH VOLTAGES.—Mandelstam & others. (Mentioned in 1755, below.)

1736. THEORETICAL CONSIDERATIONS ON A NEW METHOD OF LARGE-SCREEN TELEVISION PROJECTION: PART II.—F. Fischer & H.

Thiemann. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, Nov. & Dec. 1941, Vol. 7, Nos. 11 & 12, pp. 305–318 & 337–344 : to be contd : in German.)

For Part I *see* 3080 of 1941. The light-controlling medium is now given the name "Eidophor" (picture carrier) and the whole apparatus is termed a "Teleidoscope." The November instalment contains the following sections :—Introduction and remarks on the general behaviour of the liquid eidophor of great thickness : the general theory of the eidophor of finite thickness (including the calculation of the electric fields in the interior of the eidophor and outside it, the electric forces at the surface, the elastic displacements and internal strains, etc.) : picture synthesis and the calculation of the necessary cathode-ray current : etc.

The December instalment extends the theory to a *solid* eidophor. Here the characteristic equation is a cubic one, in contrast to the quadratic equation of the liquid eidophor : it is much more difficult to deal with and its treatment is therefore different from the previous one, but otherwise the course of the investigation is the same. The liquid and solid eidophors are merely two special cases of the general problem : the nature of an eidophor is determined by a quantity $\gamma = \alpha\lambda_0/(2G + \alpha\lambda_0)$, and this is unity for the liquid type where the elastic stresses disappear and surface tension predominates, and zero for the solid type where the surface tension is negligible compared with the elastic stresses. The type of solid material envisaged is apparently a kind of jelly consisting of a cellular lattice filled with liquid : to simplify the mathematical treatment it is assumed to be incompressible, like caoutchouc. As before, the treatment is purely theoretical and no practical points are mentioned. The next instalment will compare the picture quality obtainable with the liquid and solid eidophors.

1737. Irregularities in the Functioning of Certain Vacuum Photocells [Caesium-Silver Types, Central Anode Design, by Various Manufacturers]. — D. Cavassilas. (*Comptes Rendus* [Paris], 8th Sept. 1941, Vol. 213, No. 10, pp. 346–348.)

Certain specimens displayed marked abnormalities which disappeared, or were greatly reduced, on applying a magnetic field roughly in the cathode/anode line. These are no doubt attributable, wholly or partly, to the accumulation of negative charges on the inner wall (cells with independent cathode plate) or on the window of the bulb (Philips 3511, spherical container). "It would be interesting to examine the influence of such charges on the trajectories of the photoelectrons, and to attempt to explain thus the principal phenomena observed (discontinuity of current and spectral effect on the ratio α)."

1738. The Spectral Sensitivity of Antimony-Caesium Photocells.—M. L. Kats [Katz] & R. E. Solomonyuk. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 11, 1941, pp. 483–484.)

In view of the discrepancy in the spectral sensitivity of antimony-caesium photocells as measured by various authors, the effect on this characteristic of the value of the voltage applied to the photocell was investigated. Voltages from 45 to 1035 v were used and it was found that the general shape of the curve and the position of the maximum remained unaltered.

1739. A Selenium Photocell for Light Measurements.—E. Putseyko. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 11, 1941, pp. 485–488.)

In order to make the spectral sensitivity of a selenium photocell similar to that of the eye each cell has to be corrected separately by special light filters. In the present paper manufacturing methods are proposed for producing selenium photocells with appreciably identical spectral characteristics, enabling a standard light filter to be used.

1740. A Study of Allotropes of Selenium by the X-Ray Diffraction Method.—K. D. Gupta & B. B. Ray. (*Indian Journ. of Phys.*, Oct. 1941, Vol. 15, Part 5, pp. 389–399.)

1741. The Photoconductivity of NaCl Crystals in Strong Electric Fields.—A. N. Arsen'eva-Geyl. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 11, 1941, pp. 550–554.)

Measurements were made of the photocurrent in NaCl crystals placed in electric fields of gradients up to 7×10^5 v/cm. A rapid increase of the photocurrent with the intensity of the field was observed. A theoretical interpretation of this phenomenon is given.

MEASUREMENTS AND STANDARDS

1742. The Armed Forces and Standardisation [DIN Standards & the HgN (Army), LgN (Aircraft), MWaN (Marine), & KM (Navy) Standards].—M. Klein. (*Zeitschr. V.D.I.*, 7th March 1942, Vol. 86, No. 9/10, pp. 129–134.)

1743. General Amplitude Relations for Transmission Lines with Unrestricted Line Parameters, Terminal Impedances, and Driving Point.—R. King. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, pp. 640–648.)

"The extreme generality and surprising simplicity of the expressions . . . should make these valuable in all transmission-line problems for which less exact formulas are inadequate. These include, in particular, many transmission-line methods for making electrical measurements at ultra-high frequencies."

1744. Direct-Reading Wattmeters for Use at Radio Frequencies [Practical Instruments, the First for 500–2000 kc/s, the Second a Single-Frequency Device for Region near 50 Mc/s].—G. H. Brown & others. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 664 : summary only.)

1745. The Measurement of Small Powers with the Bolometer-Bridge.—R. Wallauschek. (*E.N.T.*, Nov. 1941, Vol. 18, No. 11, pp. 247–251.)

From the Telefunken laboratories. The method dealt with is one in which the resistance changes in the bolometer wire are measured with a bridge by the deflection method, as opposed to the null method. The corrections in general necessary are calculated: for a suitable procedure these are so small, when the power to be measured is sufficiently small, that a direct reading is correct within a first approximation. The bolometer should be worked on the linear part of its characteristic, both because calculation is then simplest and because the bolometer is then at its most sensitive.

A suitable bridge for the purpose is described: of the remaining three resistances only one need be of the highest precision, since the errors of the other two, and their mutual deviation, do not, in the first approximation, come into the measurement: it is not necessary, therefore, to balance the resistances of the leads. Two methods are given for calibrating the current in the diagonal against the resistance changes in the bolometer: a general method, in which the reactions of the altered current relations on the bolometer are allowed for by a correcting factor, and the second method, for small powers, referred to above. It is mentioned that a further advantage of working on the linear portion of the characteristic, for "a special application of the bolometer," will be dealt with in a further paper.

1746. The Measurement of Small Currents and Voltages, and Small Changes in Length, with the Bolometric Compensator [Free from the Dependence on Voltage & Temperature Fluctuations shown by Previous Bolometer Arrangements].—L. Merz & H. Niepel. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 2, Vol. 18, 1939, pp. 28–40.) A summary was dealt with in 2599 of 1941.

1747. A Wide-Range, Linear, Unambiguous, Direct-Reading Phasemeter [using a Time Ratio as a Parameter and delivering a Direct Current proportional to Phase Angle: Wide Ranges of Frequencies & Voltages: readily adapted to operation of Recorders, Servo Mechanisms, etc.].—J. E. Shepherd. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 666: summary only.)

1748. A New Capacitance and Loss-Factor Bridge for Low Frequencies, with Hand and Automatic Balancing [Combination of Schering Bridge and Complex Compensator, for Mains Frequencies: Theory & Construction: Capacitances from a Few Picofarads to some Hundreds of Microfarads].—H. Poleck. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 2, Vol 18, 1939, pp. 9–27.)

1749. A Direct-Reading Impedance Comparator for Production Testing of Receiver Coils [R.F. Bridge: Percentage Deviation in Inductance from Pre-Set Reference Standard read on Calibrated Scale on which Tolerance Limits may be marked].—F. M. Leyden & W. R. Baker. (*A.W.A. Tech. Review*, Dec. 1941, Vol. 5, No. 6, pp. 275–285.)

1750. Standard Tests on Broadcast Receivers [based on R.M.A. 1936 Standards & I.R.E. 1938 Standards].—V. V. L. Rao. (*Electrotechnics* [Bangalore], Nov. 1941, No. 14, pp. 40–49.)

1751. On the Measurement of High-Frequency Interference.—Conrad. (*See* 1659.)

1752. Distortion Tests by the Intermodulation Method [" for Commercial Testing of Audio, Radio, & General Sound-Recording Equipment "].—Hilliard. (*See* 1709.)

1753. A New Type of Apparatus for the Recording of Frequency Curves [of Amplifiers, Filters, etc., with Pass Bands between 0.1 and 21 Mc/s].—E. Legler. (*E.T.Z.*, 29th Jan. 1942, Vol. 63, No. 3/4, pp. 47–48: summary, from *Mitteil. Fernseh-A.G.*, Vol. 2, 1941, p. 50 onwards.)

A c.r. tube is used, with a 18×11 cm^2 screen: the frequency axis is linear and not logarithmic, so that a frequency of 100 kc/s corresponds to a 2 mm length. The chief point of difference compared with previous arrangements is that the variation of the test frequency is rigidly connected with the frequency scale of the indicating tube: this is accomplished as follows.

The signal generator *MG* sweeps over the range 36–44 Mc/s linearly with the exciting current of the d.c.-polarised choke forming the inductance of its oscillatory circuit: this current is of saw-tooth form and is derived from a relaxation oscillator *KG*, of frequency 25 c/s: it passes also through the deflecting coil of the c.r. tube, this coil and the choke polarising coil being in series: in this way the rigid coupling between the tube scale and the frequency is attained. To obtain the three frequency ranges 0.1–8, 6–14, and 13–21 Mc/s, one of three auxiliary oscillators, of frequencies 44, 50, and 57 Mc/s, can be switched onto the mixing stage *M*. The resulting i.f. oscillation is passed through the first stages of a wide-band amplifier: in the output circuit, any one of four resonant circuits (1, 7, 14, and 21 Mc/s) can be interposed for the checking, and occasional correction, of the test frequency against the screen scale. On the far side of these circuits is the final stage *E* of the i.f. amplifier: at the output of this the test voltage is checked by a valve voltmeter and maintained at a constant value: a potentiometer *Sp* allows the output voltage to be varied between 100 μV and 1 v, for introduction to the amplifier or filter under test, *V*, and for subsequent amplification (after rectification if necessary) and application to the c.r. tube. A reversing stage *U* can be switched in to correct the polarity of any rectifier in the amplifier under test.

1754. On the Temperature Coefficient of the Equivalent-Circuit Constants in Quartz Crystal Vibrators for Electrical Wave-Filters.—Kamayachi & Ishikawa. (*See* 1631.)

1755. The Relationship between the Voltages applied to a Quartz Crystal and the Light Intensity Distribution in the Diffraction Spectra caused by the Supersonic Waves so Produced [Voltages up to 1500 Volts].—K. N. Pogodaev. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 11, 1941, pp. 474–478.)

Experiments are conducted in connection with a new method for light modulation proposed by Mandelstam, Papalexi, & Landsberg. The method is based on the relationship between the intensity of the diffraction spectrum and the intensity of supersonic oscillations (or voltages applied to the crystal). In these experiments diffraction spectra from zero to the seventh order inclusive were studied, and voltages applied to the crystal varied from 0 to 1500 v.

1756. A Quartz Plate with Coupled Liquid Column as a Variable Resonator [Theory & Experiment].—F. E. Fox & G. D. Rock. (*Proc. I.R.E.*, Jan. 1942, Vol. 30, No. 1, pp. 29–33.)

The resonance (or oscillation) frequency of a combination consisting of a quartz plate and a coupled water column was varied over a wide range (2.2–3.0 Mc/s) by properly tuning the liquid column, and the sharpness of resonance of such a resonator was increased to some ten times that of an unloaded quartz plate similarly mounted on a support (the plate was cemented to a brass disc over an opening slightly smaller than the plate). "There is no doubt that by the use of a liquid such as mercury instead of water the sharpness of resonance could be further increased, and that this would permit an even greater shift in the resonant frequency."

1757. Longitudinal Vibrations of Square Quartz Plates.—R. Bechmann. (*Zeitschr. f. Phys.*, 1st Feb. 1942, Vol. 118, No. 9/10, pp. 515–538.)

From the Telefunken laboratories. "Systematic investigations of the longitudinal vibrations of square plates of crystalline material, especially quartz, oriented arbitrarily with respect to the crystal axes, have hitherto not been available", though papers dealing with special cases are cited and reviewed briefly, ranging from Voigt's 1928 differential equation to Builder & Benson's paper dealt with in 3440 of 1941: "In a general investigation carried out by the writer on the elastic natural frequencies of an anisotropic body of parallelepiped form (2183 of 1941) there is to be found also, as a limiting case [infinitely thin plate], a solution for the longitudinal vibrations of crystalline plates of arbitrary orientation. For a rectangular plate this solution yields three different longitudinal vibrations. In the following paper the range of validity of this solution will be investigated by measurements on numerous differently-oriented quartz plates".

From the author's summary:—"The natural frequencies are roots of a third-order equation representing the interaction of three degrees of freedom, two longitudinal and one transverse. The agreement between calculated and measured natural frequencies of the purely longitudinal vibrations is very good. For the transverse degree of freedom the frequency equation requires a correcting factor which is determined empirically [constant a: see for example eqns. 7b and 8b: its value varies slightly with δ, an average being 0.877], in order to obtain satisfactory agreement between the calculated and measured natural frequencies of the fundamental oscillations of square plates of various orientations. In addition to the three natural frequencies given by the calculations, there sometimes occurs a fourth frequency [also of the character of a longitudinal vibration (curve N_4 of Fig. 9, and bottom of pp. 535 & 537): "origin at present unknown"]. The transformations of the elasticity coefficients and the piezoelectric coefficients for arbitrary orientations of the plates, which give the electrical excitation possibilities of the natural frequencies, are carried out by means of the Euler angles for right-rotating and left-rotating quartz crystals". It has been mentioned that the calculations are based on the assumption of infinitely thin plates: in the experimental plates the ratio of side length to thickness was about 17 : 1. This can be considered as sufficient, for a check experiment with the side length kept constant and the thickness reduced to 0.5 mm gave a change of less than 0.5‰ in the vibration coefficient. The writer ends by mentioning two points which require clearing up before the processes of the longitudinal vibrations of square and rectangular plates can be considered as finally settled.

1758. Variable-Frequency Bridge-Stabilised Oscillators [incorporating Thermal Device for Amplitude Control].—W. G. Shepherd & R. O. Wise. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, p. 666: summary only.)

1759. Permeability, Inductance, and Hysteresis Resistance for Sinusoidal Field Strength and for Sinusoidal Induction.—G. Mücke. (*E.N.T.*, June 1941, Vol. 18, No. 6, pp. 121–125.)

Following Rayleigh's example, later investigators have assumed a sinusoidal field strength, involving a distortion of the magnetic induction as a result of hysteresis—the induction contains, in addition to the fundamental, all the odd harmonics. In practical measuring technique, however, it happens that sinusoidal voltages, not currents, are employed: this means that the induction, not the field strength, is sinusoidal. The writer therefore investigates whether the expressions for permeability, inductance, and hysteresis resistance, originally obtained for sinusoidal field strengths, are still valid for sinusoidal induction: he finds that the formulae for the second case are different, but that for the small magnetic forces usual in communication engineering the discrepancies are negligible in practice, being only a small percentage.

1760. The Magnetic Induction Field of Air-Core Coils and Its Application to High-Frequency Heating in Valve Manufacture.—Kirkpatrick. (*See* 1695.)

1761. A Magnetometer with Astatic System in a Homogeneous Coil Field [particularly suitable for Measurement of Low Coercive

Forces in Small Samples].—H. Neumann. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 2, Vol. 18, 1939, pp. 41–44.)

1762. An Absolute Determination of the Ampere, using Helical and Spiral Coils [including Sections on Computation of Forces between Coaxial Helices and between Helix & Spiral].—R. W. Curtis & others. (*Journ. of Res. of Nat. Bur. of Stds.*, Feb. 1942, Vol. 28, No. 2, pp. 133–157.)

SUBSIDIARY APPARATUS AND MATERIALS

1763. A New Principle for Stable D.C. Amplification [for Process Control & Other Purposes].—Eberhardt & others. (*See* 1633.)

1764. An Inertialess Commutator [primarily for a Note-Frequency Spectrometer] using Hexode Valves in a Controlled-Saturation Connection.—Vetterlein. (In paper dealt with in 1710, above.)

1765. Image Errors occurring in the Deflection of a Cathode-Ray Beam in Two Crossed Deflecting Fields.—Wendt. (*See* 1732.)

1766. On the Motion of an Electric Particle.—Opatowski. (*See* 1601.)

1767. Trajectories of Monoenergetic Electrons, in an Arbitrary Static Electromagnetic Field, in the Neighbourhood of a Given Trajectory.—MacColl. (*Journ. of Math. & Phys.* [of M.I.T.], Dec. 1941, Vol. 20, No. 4, pp. 355–369.)

From the Bell Telephone Laboratories. "Much of the existing theory of electron optics is concerned with the study of the trajectories in the neighbourhood of the axis of a static axially symmetric electromagnetic field. In the present paper this theory is generalised in that we consider electrons moving with fixed total energy E in an arbitrary static electromagnetic field, and we study the trajectories in the neighbourhood of an arbitrary trajectory T_0. Specifically, we investigate the various types of images which can be formed, the conditions for their formation, the various types of distortion to which the images are subject, etc. This general problem seems to have been discussed on only one previous occasion (Cotte, 2921 of 1939 and back reference [also 663 of 1938]), and then with but little overlapping of the discussion given here. We confine our attention to 'first order effects,' in the sense that certain distances, which characterise the departures of the trajectories under consideration from the basic trajectory T_0, are assumed to be so small that their squares and products can be neglected . . ."

1768. The Effect of Space Charge on the Potential and Electron Paths of Electron Beams.—Petrie. (*See* 1684.)

1769. The Most Favourable Form of the So-called "Mat" Coils for Magnetic Deflection in Cathode-Ray Tubes.—Scholz. (*See* 1733.)

1770. Factors governing Performance of Electron Guns in Television Cathode-Ray Tubes.—Law. (*See* 1731.)

1771. Theoretical and Experimental Researches on Electron Radiators [primarily in connection with X-Ray Tubes].—Dosse. (*E.T.Z.*, 16th Jan. 1941, Vol. 62, No. 3, pp. 57–58: summary, from *Zeitschr. f. Phys.*, Vol. 115, 1940, p. 530 onwards.)

On the basis of the Maxwellian velocity-distribution, Law has calculated the current density at the focus as a function of the distance of the point of measurement from the axis: his equation involves the total current, the accelerating voltage, and an unknown constant a. The writer finds a value for a in terms of the true cathode temperature and the focal length, and from this he derives other relations important in regard to the merit of an arrangement. The theoretical results are satisfactorily confirmed by tests with the special ray-measuring device of Fig. 3, except that a definite relation between focal-spot size and cathode temperature has not so far been established.

1772. The Application of the Cathode-Ray Oscillograph to the Measurement of the Inclination Vector.—Goncharski. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 11, 1941, pp. 479–482.)

A method is proposed in which the inclination of a system, for example of a pendulum, can be determined at a remote point by observing a vector on the screen of an oscillograph. The magnitude and direction of this vector indicate respectively the degree and sense of the inclination of the system. In the example considered (Fig. 1) a coil 2 is attached to the suspension of the pendulum. Round this coil four other coils 3 are mounted and fed with two- or three-phase current. A rotating magnetic field is thus produced, but an e.m.f. is induced in coil 2 only if the pendulum, and therefore the coil, are inclined. The e.m.f. so generated is transmitted to the plates of the oscillograph. At the same time one of the voltage phases feeding coils 3 is transformed into short impulses whose phase depends on the direction of the inclination of the pendulum. The impulses are transmitted to the modulating electrode of the oscillograph and a dark radial line is obtained on the luminous circle on the oscillograph screen. The theory and accuracy of the method are discussed in detail and a modification of the method proposed is also considered.

1773. Increasing the Resolving Power of the Emission-Type Electron Microscope.—Boersch. (*Naturwiss.*, 20th Feb. 1942, Vol. 30, No. 8, p. 120.)

Brüche & Knecht (853 of 1935) gave the resolving power of such a microscope as 3μ, and since then nothing has been heard of an experimental raising of this value. Since the problem is important for the metallographic, thermionic, and photoelectric research on surfaces, the writer has tried to accomplish this. A directly heated molybdenum ribbon was magnified with a purely electrostatic immersion objective of the Brüche-Johannson type (Johannson, 1934 Abstracts, p. 51). In order to use higher voltages (30 kv instead of the previous 2 kv) and higher field strengths (150 kv/cm instead of 20 kv/cm) between Wehnelt cylinder and anode, the system had to be modified on the basis of previous experience in the development of high-voltage lenses (the reference given is meaningless, but *see* 1571 of 1940): further, the system of internal photography was adapted to electron-microscopy, so that the coarse grain of the fluorescent screen was replaced by the fine grain of the photographic film. As a result of these changes the resolution was increased from 3μ to 0.07μ (Fig. 3), which is better than the 0.2μ of the optical microscope and even than the theoretical limit for the emission microscope, given by Recknagel as 0.13μ for the same conditions (field strength at cathode 30 kv/cm: 514 of February). Moreover, the experimental construction of the objective could be improved as regards axiality, and this and other improvements would no doubt raise the resolving power still further: another step forward would be the use of indirect heating, to eliminate the magnetic field due to the current along the molybdenum foil. Since the aperture error is an important factor in limiting the resolving power, precautions taken in the transmission-type microscope to reduce this error (*see* Boersch's "The Problem of Image Formation," *Physik. Berichte*, 1st Dec. 1940, Vol. 21, No. 23, p. 2300), such as the introduction of stops, would effect a further improvement in the present case: in this connection the writer's experiments with very small stops made of 0.015 mm platinum foil and introduced at the anode (1174 of 1941) showed that these would stand up to the heat resulting from electron bombardment if they were protected by larger stops in front of them.

In the actual experimental model the immersion objective (Fig. 1) had a focal length of 3.06 mm: the distance between the Wehnelt cylinder (1.3 mm diameter) and the anode was 2 mm.

1774. Further Developmental Work on the Universal Electron Microscope [leading to Latest Type with Alternative Magnetic (0.9 mm) or Electrostatic Objective, for Bright-Field or Dark-Field Working, Stereoscopic Working: with Object Shading (for Protection of Sensitive Objects), Object Reaction Chamber, Object Heating: Vacuum Film Camera: Electron Diffraction Working: etc.].—von Ardenne. (*Physik. Zeitschr.*, Jan. 1942, Vol. 43, No. 1/2, pp. 11–15.) This is the paper referred to in 1250 of April. *See* also 1775, below, and 3595 of 1941.

1775. Heating-Supermicroscopy with the Universal Electron Microscope.—von Ardenne. (*Kolloid Zeitschr.*, No. 3, Vol. 97, 1941, p. 257 onwards.) Referred to in the paper dealt with in 1774, above, where the special importance of the provision of object-heating for electron-diffraction work is emphasised.

1776. The Extension of the Range of Working of Magnetic Voltage Stabilisers.—Beck. (*E.T.Z.*, 12th Feb. 1942, Vol. 63, No. 5/6, pp. 57–60.)

From the Siemens & Halske laboratories. The well-known stabiliser consisting of an unsaturated choke as a series element and a saturated-choke/condenser combination as a parallel element has hitherto been used to reduce mains fluctuations of up to ± 20% to a value around ± 1%: for a constant load the fluctuations can be reduced to ± 0.5% or less. These stabilisers have been employed on mains systems of different voltages, but such a use has meant a good deal of changing-over of series and parallel chokes, and for a long time it has been desired to obtain a voltage stabiliser which could be used without change on all the customary mains voltages: in Germany this would mean an extension of the range to 90–250 v, a variation of ± 47% about a middle value of 170 v.

A thorough investigation of the vector diagrams, under various conditions, of the original circuit led to the conclusion that what was required was a full utilisation of the saturation choke, to give an extended range, and a reduction in the value of the series choke, to give efficiency. Instead of the fundamental circuit of Fig. 1a, the "wide-range stabiliser" circuit of Fig. 1c was adopted, the inductance of the series choke being reduced to about half the usual value. This reduction increased the danger of excitation of relaxation oscillations, well known to occur in resonant circuits consisting of a condenser and a saturated choke (*see*, for example, Aretz, 2119 of 1936), but this defect was eliminated by the introduction, in series with the condenser, of a suitable air-gapped choke to de-tune the circuit as regards the second harmonic which is found to be the cause of the trouble: this choke is included in Fig. 1c. The stabiliser thus obtained has a working range of 90–250 v and gives a ± 2% no-load/full-load control. If designed for special accuracy and without troubling too much about efficiency and economy, the output voltage can be kept within ± 1%.

1777. On the Parameters of an Impulse Generator operating with a Discharge Tube.—Korsunski. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 11, 1941, pp. 561–575.)

It is pointed out that discharge tubes operating at voltages of the order of a megavolt impose special requirements on the associated impulse generator. An equivalent circuit of the system (Fig. 1) is given and the theory of operation is discussed in detail. Formulae are derived for determining the generator voltage and the current flowing in the generator circuit before and during the discharge. A number of calculated and experimental curves are shown and the effects of various parameters of the generator on the spectrum of the particles generated by the tube are considered. The main conclusion reached is that contrary to the usual practice an impulse generator to operate with a discharge tube should possess large self-inductance, large parasitic capacity, and low damping.

1778. A New Induction Accelerator generating 20 MeV [originally called "Rheotron"].—Kerst. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, pp. 93–94.) For previous work *see* 3130 of 1941 and back reference: for a discussion of the name "Betatron" see *Science*, 23rd Jan. 1942, Vol. 95, Supp. p. 8: *see* also *Sci. News Letter*, 27th Dec. 1941, Vol. 40, No. 26, p. 403.

1779. On the Theory of the Electron-Plasma Oscillations.—Seeliger. (*See* 1685.)

1780. The Contact Converter [" K-Converter," for Rectification of Polyphase Current: with Mechanically Opened & Closed Contacts protected against Arcing by Device of D.C.-Polarised Iron-Cored Chokes: High Efficiency].—Koppelmann. (*E.T.Z.*, 2nd Jan. 1941, Vol. 62, No. 1, pp. 3–16: Discussion pp. 16–20.)

1781. Selenium Rectifiers for Closely Regulated Voltages [particularly a Controlled-Output-Voltage Circuit using Regulating & Shunt Reactors].—Yarmack. (*Elec. Communication*, No. 2, Vol. 20, 1941, pp. 124–131.) Some sections have already appeared elsewhere (*see* 247 of January). The paper supplements that of Clarke (825 of March).

1782. The Electron Theory of Crystalline Compounds of the Type of Copper Oxide [Limitations of Present Theory: Energy of Internal Ionisation: Other Possible Mechanisms].—Dressnandt. (*Sci. Abstracts*, Sec. A, Dec. 1941, Vol. 44, No. 528, p. 399.)

1783. Contribution on the Sense of Rectification in Semiconductors [Measurements on Sintered Bodies made from CdO, TiO_2 (both of Reduction or " Surplus " Type), NiO (Oxidation or " Defect " Type), & CuO (Type still Contested), with View to Further Confirmation of Schottky's Rule of Polarity].—Klarmann. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 2, Vol. 18, 1939, pp. 78–83.)

1784. Wear and Friction in Sliding Contacts, particularly between Carbon Brushes and Copper Rings [Influence of Pressure, Velocity, Moisture, & Current Strength: etc.].—Holm & others. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 1, Vol. 18, 1939, pp. 73–100.) For later work *see* 860 of March.

1785. New Observations on Silver Contacts [Cathode Contact " formed " by Gradual Increase of Current, so that Limiting Current is about Doubled].—Burstyn. (*E.T.Z.*, 13th Feb. 1941, Vol. 62, No. 7, pp. 149–150.)

1786. The Inductance of a " Sieve " Contact.—Störmer. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 2, Vol. 18, 1939, pp. 45–53.)

" If two metal parts furnish an electrical connection only through a very small surface of contact, such a contact presents to the current a resistance which Holm, in analogy to the resistance which a sieve presents to a flow of water forced through it, calls a ' sieve ' resistance, the contact itself being termed a ' sieve ' contact. At such a contact the current flow lines are strongly compressed at the point of contact, and for the use of contacts in h.f. technique it is therefore important to know whether, as a result, any appreciable inductance does or does not appear, since the design of a contact might in some cases depend on this."

The question is treated mathematically with certain simplifying assumptions. The results, applied to a relay with perfectly clean silver contacts with a pressure of 100 gms and certain likely dimensions, show that at a frequency no higher than about 32 kc/s the inductive resistance of the contact is already as great as its ohmic resistance. In practice, however, the contact is coated with some kind of extraneous film and its ohmic resistance is considerably greater than that of the clean contact, so that in general the contact inductance may be neglected, provided that the permeability μ of the material is not too high.

1787. High-Conductivity Beryllium-Cobalt-Copper Alloy [Mallory 73 Beryllium Copper: for Current-Carrying Springs, etc.].—(*Engineering*, 10th April 1942, Vol. 153, p. 287.)

1788. Thermostat Metal [Bimetallic Sheet & Strip].—Hood. (*ASTM Bulletin*, Jan. 1942, No. 114, pp. 11–14.)

1789. The Use of Infra-Red Lamps for Heating and Drying.—Haynes. (*Bull. Assoc. suisse des Élec.*, 14th March 1941, Vol. 32, No. 5, p. 86.) Summary of a lecture based partly on the paper dealt with in 1200 of 1941.

1790. A Note on the Use of Baking Shellac Varnishes for coating Graphite-on-Glass Resistances in the Laboratory [for D.C. Amplifiers, etc: Successful Comparison with Glyptal Lacquer Coatings].—Bhattacharya. (*Indian Journ. of Phys.*, Feb. 1941, Vol. 15, Part 1, pp. 59–62.)

1791. Fixed Resistances for Radio Purposes [Summary of Methods of Manufacture of Composition & Wire-Wound Vitreous-Enamelled Resistances].—Iyengar. (*Electrotechnics* [Bangalore], Nov. 1941, No. 14, pp. 50–53.)

1792. On the Temperature Rise of Solid Insulating Materials at Ultra-High Frequencies [Method using Small Radial Sticks of Polystyrol Resin or Fused Silica, stuck to Surface with Waxes of Different Melting Points, as Indicators, Time of Collapse being measured: Some Results at 94 Mc/s: Alternative Use of Colour-Changing Paints].—Okazaki & Otuka. (*Electrotech. Journ.* [Tokyo], Feb. 1941, Vol. 5, No. 2, pp. 37–38.) *See* also 1793, below.

1793. Disfigurement of Hard Rubber due to Dielectric Loss under Ultra-High-Frequency High-Voltage Fields [and Comparison with Steatite, etc.].—Okazaki & Ohtsuka. (*Electrotech. Journ.* [Tokyo], Feb. 1941, Vol. 5, No. 2, pp. 38–39.) *See* also 1792, above.

1794. Temporary Protection for Cable Splices [Use of " CR " Tape, Tough Vulcanised Rubber lined with Tacky Unvulcanised Rubber].—Pike. (*Bell Lab. Record*, Feb. 1942, Vol. 20, No. 6, pp. 159–162.) *Cf.* 1531 of May.

1795. Synthetic Rubber [Short Survey].—Hayden. (*Engineer*, 3rd April 1942, Vol. 173, pp. 285–287.)

1796. THE PLASTIC FLOW FROM CENTRAL ORIFICES OF VARIOUS FORMS.—Unckel. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 22, 1941, pp. 245–248.) Extension to 837 of March.

1797. CRYSTALLINITY IN CELLULOSE ESTERS [X-Ray Diffraction Studies of Plastics].—Baker. (*Bell Lab. Record*, Feb. 1942, Vol. 20, No. 6, pp. 155–158.) *See* also 1507 of May.

1798. SILICONES [By-Products of Silicon/Carbon Compounds] AS HEAT-RESISTING INSULATING RESINS.—(*Sci. News Letter*, 28th Feb. 1942, Vol. 41, No. 9, p. 143 : paragraph only.)

1799. PLASTICS [including the New Polymers of Methyl Silicone & Related Compounds].—Yarsley. (*Electrician*, 27th March 1942, Vol. 128, pp. 288–289.)

1800. A HIGH-FREQUENCY CERAMIC INSULATOR FIT FOR MACHINING [Search for Insulator with Low Dielectric Loss, No Shrinkage by Heat Treatment, Suitable for Machining, Stable against Moisture & Chemicals : resulting in Development of " Teison No. 2 "].—Kobayashi & others. (*Electrotech. Journ.* [Tokyo], Feb. 1941, Vol. 5, No. 2, p. 40.)

1801. THE TITROMETRIC DETERMINATION OF THE PERMEABILITY TO WATER OF INSULATING MATERIALS [in place of the Usual Gravimetric Methods : Application to Styroflex, Benzyl-Cellulose, & Whale Oil (as Substitute for Linseed Oil) : Equal Permeabilities for Vapour & Liquid : etc.].—Nagel & Brandenburger. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 2, Vol. 18, 1939, pp. 97–104.)

1802. ON THE THERMAL CONDUCTIVITY OF DIELECTRICS.—Pomeranchuk. (*Phys. Review*, 1st Dec. 1941, Vol. 60, No. 11, pp. 820–821.)

1803. ON THE DISCHARGE LAG IN SOLID INSULATING MATERIALS.—Strigel. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 1, Vol. 18, 1939, pp. 101–119.)

Measurements, with the " time transformer " (*see* for example 1933 Abstracts, p. 225), on materials of very diverse structures, such as glass, mica, Resistit (laminated mica/paper composition), pressboard, and nitrocellulose, some in air and some in insulating liquids. Among other results, it was found that solid insulating materials can be divided, as regards the potential dependence of their discharge delays, into two classes : for those with crystal structure (mica) or crystalline structure (porcelain) the building-up time for breakdown was well below 1 μs when the surge ratio (*i.e.* ratio of surge potential to static a.c. breakdown potential) was only 1.2, whereas for fibre-containing materials such short times were only reached for surge ratios over 2.0.

1804. NOTE ON MECHANISM OF THE ELECTRICAL BREAKDOWN IN IONIC CRYSTALS [Suggested Explanation of Failure of Fröhlich's Theory (based on von Hippel's Picture) at High Temperatures].—Suita. (*Electrotech. Journ.* [Tokyo], March 1941, Vol. 5, No. 3, p. 60.)

1805. THE BREAKDOWN STRENGTH OF MIXTURES OF DIELECTRIC LIQUIDS [Hexane/Heptane, Heptane/Xylol, Heptane/Nitrobenzol, etc.].—Ruhle. (*Arch. f. Elektrot.*, 30th Sept. 1941, Vol. 35, No. 8, pp. 490–501.)

" It is of great theoretical and practical interest to learn the behaviour of liquid insulating materials consisting of several components. For theory, the information may bring a new contribution to our understanding of the breakdown mechanism. Practically, such investigations are important for the use of mixtures of various mineral oils and for the preparation of synthetic insulating oils." The tests were all at 50 c/s. Among the results, it was found in most cases that the breakdown voltage was independent of the concentration of the mixtures, so long as the components had equal breakdown strengths ; but that if one had a lower strength, a quite small percentage of it produced a large decrease in the breakdown voltage : increasing the percentage had little or no further effect. A special behaviour was shown by the halogen derivatives of the aromatic hydrocarbons : the addition of a small percentage led to a raising of the breakdown voltage by 30–40%. Increasing the percentage beyond a certain point produced a large drop. The position and width of the maximum differed with different kinds of added substance : chlorbenzol gave a particularly broad maximum and seems therefore particularly suitable for such use (Fig. 6).

1806. THE MIXED-BODY PROBLEM IN CONDENSER TECHNIQUE. — Büchner (with Zauscher). (*Wiss. Veröff. a. d. Siemens-Werken*, No. 2, Vol. 18, 1939, pp. 84–96.)

In applying the " mixture " formulae to the problems of practical condenser design, the important points are not merely the synthesis of the dielectric constant of the mixed body from those of its components but also the question of the influence on it of the always present losses and the dependence of the mixed-body losses on the individual losses of the components. Of particular value is the equation obtained by Lichtenecker & Rother, $\epsilon^k = \delta_1\epsilon_1{}^k + \delta_2\epsilon_2{}^k$, which has worked well in many cases : here k is a constant dependent on the form and distribution of the components but not on the ratios of their amounts, and δ_1 and δ_2 are the " volume shares " of the components : k may have any value between $+ 1$ and $- 1$. For $k = 1$ this formula becomes that for the parallel connection of the two components, $\epsilon = \delta_1\epsilon_1 + \delta_2\epsilon_2$, while for $k = -1$ it becomes that for the series connection, $1/\epsilon = \delta_1/\epsilon_1 + \delta_2/\epsilon_2$; for $k = 0$ it becomes the Lichtenecker logarithmic mixing rule, $\log \epsilon = \delta_1 \log \epsilon_1 + \delta_2 \log \epsilon_2$. All these formulae can be extended directly to any number of components, so that finally a formula is obtained for a mixed body of n components, $\epsilon^k = \sum_{i=1}^{n} \delta_i\, \epsilon_i{}^k$. This eqn. 5, like the others, is based on the implicit assumption that no energy is lost in the individual components : the complex dielectric constant of a dielectric possessing losses is given by eqn. 6, and the introduction of this into eqn. 5 yields eqn. 8 for the resultant loss factor of a multi-component body (simplifying to approximate formulae eqns. 9 & 10 under certain conditions) and eqn. 11 for its dielectric constant. For the special case when $k = 0$ (logarithmic mixing rule) the equations are given at the end of section 1.

Section 2 deals with the range of applicability of the basic Lichtenecker-Rother formula, the work of Bruggeman (2424 of 1936 and 1087 of 1937) being discussed here. An important application is to porphyrous mixed bodies, and section 3 begins by considering those bodies in which Rutile is added to obtain high dielectric constants (Fig. 3): the logarithmic mixing rule gives a good approximation here. The most important condenser type is the impregnated paper condenser and the question arises as to which mixing formula best represents the paper structure: a comparison between the "two-dimensional lamellar" and "two-dimensional cylindrical" formulae of Bruggeman, the above-discussed logarithmic rule, Rayleigh's cylinder formula, and the "series connection" formula mentioned above (case $k = -1$), shows that the last gives results both for the dielectric constant and dielectric losses which agree best with measured values. The reason for the good results given by this simple two-layer series formula over such wide ranges of paper and impregnating material is examined, and finally the influence of the oil or air-filled space between dielectric and metal coating in condensers is discussed.

1807. Remarks on My Paper "Modern Condensers for Communication Engineering and Their Development" [Addition of Data for "Tempa S," and the Possibility, afforded by Ceramic Condensers only, of building Condensers with Any Desired Temperature Coefficient between $+120$ and -700×10^{-6}/°C: Suitable Parallel or Series Connection gives Any Coefficient within $\pm 10 \times 10^{-6}$/°C].—Linder. (*E.T.Z.*, 6th Feb. 1941, Vol. 62, No. 6, p. 142.) *See* 555 of 1941.

1808. Permeability, Inductance, and Hysteresis Resistance for Sinusoidal Field Strength and for Sinusoidal Induction.—Mücke. (*See* 1759.)

1809. Magnetic Materials for Transformers, particularly Instrument Transformers [with Curves of Hyperms 1 to 5: Hyperm 20 for H.F. Technique, with Permeability scarcely decreasing with Increasing Frequency, & High Specific Resistance keeping down the Eddy-Current Losses at Very High Frequencies].—Meyer & Fahlenbrach. (*E.T.Z.*, 2nd Jan. 1941, Vol. 62, No. 1, p. 21: summary, from *Tech. Mitt. Krupp.*)

STATIONS, DESIGN AND OPERATION

1810. Automatic Radio Relay Systems for Frequencies above 500 Megacycles.—Smith. (*See* 1725.)

1811. A Short-Wave Radio-Telephone Transmitter and Receiver built like Large-Scale "French" Handset [held to Mouth & Ear: Weight 4 lb: Range about 1 Mile].—(*Sci. News Letter*, 28th Feb. 1942, Vol. 41, No. 9, p. 143: paragraph only.)

1812. A Low-Power Installation for Ultra-High-Frequency Radio-Telephone Links [5-Watt Transmitter combined with 6-Valve Superheterodyne Receiver, for Duplex Operation at Fixed Frequency in 30–45 Mc/s Band: Single Crystal controls both Transmitter & Receiver: Simple Bell-Calling System].—Honnor & Trew. (*A.W.A. Tech. Review*, Dec. 1941, Vol. 5, No. 6, pp. 287–294.)

1813. The Police Wireless System of the Town of Zurich [Use of Frequency Modulation: Remote-Control U.S.W. Receivers mounted on Top of Serious Obstacles: etc.].—Wertli. (*Bull. Assoc. suisse des Élec.*, 19th Dec. 1941, Vol. 32, No. 25, pp. 711–717: in German.)

1814. Design Considerations of Ultra-High-Frequency Aircraft Equipment.—Gardner. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 605: summary only.) From the Wilcox Electric Company.

1815. The Use of Radio in Modern Air Transports.—Knox. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 605: summary only.) From Northwest Airlines.

1816. A New Marine Radio Unit for Cargo Vessels [prompted by U.S.A. Programme of Mass Production of Merchant Vessels].—Girard. (*Elec. Communication*, No. 2, Vol. 20, 1941, pp. 71–72.)

1817. Modern Marine Communication Equipment [including the *America's* Installation: the Use of Inductance Tuning: etc.].—McDonald. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 605: summary only.) From the Radiomarine Corporation.

1818. The Modulation and Demodulation Method using the Condensers of Periodically Varying Capacity [with Applications to Remote Measurement & Secret Communication: Analysis].—Tomituka. (*Electrot. Journ.* [Tokyo], March 1941, Vol. 5, No. 3, pp. 43–44.)

1819. Diplex [Transradio Internacional System giving Two Messages in One Direction by Transmitter with Output commutated from One Frequency to Another at a Rhythm superior to Keying Rhythm].—Noizeux, Krähenbühl, & Noviks. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, pp. 609–613.) *Cf.* Gracie's independent paper, 693 of 1938.

1820. Some Aspects of the Problem of the Utilisation of the Radioelectric Frequencies [including Future Possibilities: Doubtful Desirability of American "Channel" System for Europe: etc.].—Corbaz. (*Bull. Assoc. suisse des Élec.*, 29th Aug. 1941, Vol. 32, No. 17, pp. 411–416: in French.) Concluded from No. 16.

GENERAL PHYSICAL ARTICLES

1821. "Jüdische und deutsche Physik" [" Jewish & German Physics ": Extremely Critical Book Review].—Müller & others. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 23, 1942, p. 25.)

1822. The Physical Interpretation of Quantum Mechanics [Bakerian Lecture]. — Dirac. (*Proc. Roy. Soc.*, Ser. A, 18th March 1942, Vol. 180, No. 980, pp. 1–40.)

1823. Thermodynamic Functions for Two-Dimensional Quantum Statistics [with Application to Deduction of Magnetic Susceptibility of Free Electron Gas when Electrons are confined to a Plane].—Singh. (*Indian Journ. of Phys.*, Feb. 1941, Vol. 15, Part 1, p. 73–78.) For the application *see* 557 of February.

1824. A General Theorem on the Initial Curvature of Dynamical Trajectories.—Kasner & Mittleman. (*Proc. Nat. Acad. Sci.*, Feb. 1942, Vol. 28, No. 2, pp. 48–72.)

" If a particle starts from 'maximum rest' in an acceleration field of order n, the initial curvature of the trajectory is $n!\,(n-1)!\,/(2n-1)!$ times the curvature of the line of force through the initial position."

MISCELLANEOUS

1825. Elliptic and Spheroidal Wave Functions.—Chu & Stratton. (*See* 1594.)

1826. Laplace Transformation and Operational Calculus, *and* A Basis for the Complex Calculation of Alternating - Current Problems.—Wagner : Landolt. (*See* 1637 & 1638.)

1827. On the Representation of an Experimental Function by a Rational Fraction.—Vernotte. (*Comptes Rendus* [Paris], 29th Sept. 1941, Vol. 213, No. 13, pp. 433–435.)

1828. A Method of Successive Approximations of Evaluating the Real and Complex Roots of Cubic and Higher-Order Equations, *and* A Comparison of Methods for Evaluating the Complex Roots of Quartic Equations [in Study of Damped Vibrations].—Lin : Sharp. (*Journ. of Math. & Phys.* [of M.I.T.], Aug. 1941, Vol. 20, No. 3, pp. 231–242 : pp. 243–258.)

1829. On a Class of Singular Integral Equations [Solution of Equation

$$f(x) = h(x) + \int_0^\infty k(x-y)f(y)dy \quad (0 < x < \infty)].$$

—Reissner. (*Journ. of Math. & Phys.* [of M.I.T.], Aug. 1941, Vol. 20, No. 3, pp. 219–223.)

1830. A Least-Square Procedure for solving Integral Equations by Polynomial Approximation [Improved Technique giving Much Greater Accuracy].—Hildebrand & Crout. (*Journ. of Math. & Phys.* [of M.I.T.], Aug. 1941, Vol. 20, No. 3, pp. 310–335.) Illustrated by application to charge-distribution problems : for the previous paper *see* 1670 of 1940.

1831. The Cinema Integraph in Interreflection Problems [Multiple Reflection of Radiant Energy between Reflecting Surfaces or between Parts of Same Surface : Use of Cinema Integraph (4107 of 1940) for Numerical Solution of Buckley's Integral Equation].—Hedeman. (*Journ. of Math. & Phys.* [of M.I.T.], Dec. 1941, Vol. 20, pp. 402–417.)

1832 Mathematical Theory of the Differential Analyser.—Shannon. (*Journ. of Math. & Phys.* [of M.I.T.], Dec. 1941, Vol. 20, No. 4, pp. 337–354.)

1833. " Six-Place Tables " [Book Review].—Allen. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, pp. 606–607.)

1834. The Distribution of a Product from Several Sources to Numerous Localities [Calculation of Least Costly Manner of Distribution from Several Factories].—Hitchcock. (*Journ. of Math & Phys.* [of M.I.T.], Aug. 1941, Vol. 20, pp. 224–230.)

1835. Joint Meeting to discuss the Application of Statistical Control of the Quality of Materials and Manufactured Products.—Darwin : Gill. (*Engineer*, 27th March 1942, Vol. 173, pp. 266–267.) For a long report see *Electrician*, 24th April 1942, Vol. 128, pp. 388–393 : also Editorial, pp. 383–384.

1836. Quality Control in Manufacture.—Rissik. (*Electrician*, 27th March 1942, Vol. 128, pp. 276–280.)

See also *Times* leader, 16th April 1942. For previous work *see*, for example, Shewhart, 1930 Abstracts, p. 527 (r-h column) ; 1933 Abstracts, p. 519 (l-h column) ; 3647 of 1940 ; and 1837, below, which also gives important references : Rissik, 625 of 1941, 297 of January, and 1565 of May : Dudding & Jennett, O'Dea, 3646 of 1940 : Peters & van Voorhis, Simon, 1194/5 of April.

1837. Contribution of Statistics to the Science of Engineering : a Survey of the Potential Contributions of Statistics to the Science of Engineering as a National Asset.—Shewhart. (*Bell Tel. S. Tech. Pub.*, Monograph B-1319, 28 pp.)

1838. A New High-Sensitivity System of Factory Control of Raw Material by measuring the Magnetic Permeability.—Yanus & others. (*Journ. of Tech. Phys.* [in Russian], No. 10, Vol. 11, 1941, pp. 936–946.)

The theory and practical applications are discussed of a method in which the material is pulled through a magnetising coil (or between two coils in the case of sheet material) and the magnetic flux in the material observed with the aid of another coil. It is shown that a much higher sensitivity is obtained with an open magnetic circuit, *i.e.* without the yoke over the magnetising coil.

1839. Correction to " Determination of the Static and Dynamic Constants by means of Response Curves ".—Bernhard. (*Journ. Applied Phys.*, Feb. 1942, Vol. 13, No. 2, p. 116.) *See* 905 of March.

1840. Panoramic X-Ray Equipment [All Points of View combined in One Exposure: Ring-Shaped Source].—Schiebold. (*Sci. News Letter*, 24th Jan. 1942, Vol. 41, No. 4, p. 57.)

Note on a German patent: particularly for crystal structure, etc. *See* also note in *Industrial & Engineering Chemistry* (*News Edition*), 10th Dec. 1941, Vol. 19, No. 23, p. 1408.

1841. Output of an X-Ray Tube in Relation to a High-Voltage Multiplying Scheme, *and* On X-Raying of Commercial Goods and Detection of Interior Defects of Different Density.—Revutzkaja & Akatnova: Trapeznikov. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 11, 1941, pp. 254–258: pp. 259–265.)

1842. The Determination of the Thickness of Electrolytic Coatings: Part 2.—Gepshteyn [Gepstein] & others. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 11, 1941, pp. 525–531.)

An experimental verification of a method proposed by Palatnik (*ibid.*, Vol. 10, 1940, p. 1975) in which use is made of X-ray spectrograms. Nickel and tin coatings of thickness between 0.1 and 10 μ were measured.

1843. Some Aspects of the Impact of War Economy on Civilian Radio [Symposium].—Horle & others. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 603: summaries only.)

1844. A.R.P. in the Electrical Industry.—Brierly. (*BEAMA Journal*, Jan., Feb., & March 1942, Vol. 49, Nos. 55/57.)

1845. Obituary: Sir W. H. Bragg, O.M., K.B.E., F.R.S.—(*Engineering*, 20th March 1942, Vol. 153, pp. 234–236: *Nature*, 28th March 1942, Vol. 149, pp. 346–351.)

1846. Peder Oluf Pedersen: 1874–1941.—(*Elec. Communication*, No. 2, Vol. 20, 1941, pp. 133–135.)

1847. "Ingenieure" [Discussions on the Significance, Vocation, & Position of Engineers: Book Review].—Münzinger. (*E.T.Z.*, 12th Feb. 1942, Vol. 63, No. 5/6, pp. 78–79.) An enthusiastic review.

1848. Discussion on "A Critical Review of Education and Training for Engineers."—Fleming. (*Electrician*, 27th March 1942, Vol. 128, pp. 280–282.) *See* also *Nature*, 2nd May 1942, pp. 482–483.

1849. Physicists after the War [Summary of Royal Institution Lecture].—Bragg. (*Engineering*, 3rd April 1942, pp. 272–273.)

"Real advance demands constant contact with other people and outside ideas. No man wakes up in the morning and says, 'I'll have a bright idea to-day.' Bright ideas result from the clash of intellects: they have two parents."

1850. The Comparative Cost of Loan Service and of Microfilm Copying in Libraries.—Seidell. (*Science*, 28th Nov. 1941, Vol. 94, pp. 515–516.)

1851. Radio Progress during 1941: Electronics, Radio Transmitters and Transmitting Antennas, Radio Receivers, Frequency Modulation, Television & Facsimile, Propagation, Piezoelectricity, Electroacoustics.—(*Proc. I.R.E.*, Feb. 1942, Vol. 30, No. 2, pp. 57–71.)

1852. "Questions and Answers in Electrical Engineering Practice," *and* "Questions and Answers in Radio-Communication" [Book Reviews].—Dharap. (*Electrotechnics* [Bangalore], Nov. 1941, No. 14, p. 65: p. 65.) The questions were set in examinations held by the City & Guilds of London Institute.

1853. "Radio at Ultra-High Frequencies: Part I" [Transmitting, Propagation & Relaying, Measurements, Reception: etc: Book Review].—RCA Institutes Technical Press. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 607.)

1854. Influence of the Wave-Source Area on the Amplitude of Soil Vibrations, *and* The Choice of the Depth of the Source and Receiver of Waves propagating in the Soil.—Barkan. (*Journ. of Tech. Phys.* [in Russian], No. 11, Vol. 11, 1941, pp. 1014–1019: pp. 1020–1028.)

1855. A Method of minimising Supercooling, and Its Application in the Determination of Freezing Points [of Soils, etc.] from Dielectric-Constant Measurements.—Shaw. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, pp. 2–5.)

1856. An Investigation of the Properties and Applications of the Geiger-Müller Photoelectron Counter [Nickel Type: Sensitivity estimated as Comparable with That of Eye, Less than That of Liquid-Air-Cooled Electron Multiplier (750 Quanta per Second compared with 4), Comparable (although Action is Non-Accumulative) to Photographic Plate: Other Counters].—Duffendack & Morris. (*Journ. Opt. Soc. Am.*, Jan. 1942, Vol. 32, No. 1, pp. 8–24.)

1857. An Arrangement for the Geiger-Counter Study of Weak Radioactivities [Sensitivity more than Doubled by Elimination of Responses to Cosmic Radiation].—Berthelot. (*Comptes Rendus* [Paris], 23rd June 1941, Vol. 212, No. 25, pp. 1087–1090.)

1858. Helium-Filled Geiger-Müller Counters [Best Plateau & Lowest Threshold given by Helium/Methyl-Alcohol].—Kapur & others. (*Current Science* [Bangalore], Dec. 1941, Vol. 10, No. 12, pp. 521–522.)

1859. Directional Properties of Self-Quenching Counters [Stever's "Small-Bead-on Wire" Method: "Segmented Counter" Method], *and* The Discharge Mechanism of Fast G-M Counters from the Deadtime Experiment.—Ramsey: Stever. (*Phys. Review*, 1st/15th Jan. 1942, Vol. 61, No. 1/2, pp. 90–97: pp. 38–52.)

1860. THE "ULTRA" INCENDIARY BOMB DETECTOR.—Ultra Electric. (*Electronic Eng:g*, Aug. 1941, Vol. 14, No. 162, p. 339.) For a test report *see* September issue, p. 424.

1861. EXACT CONTROL OF A LUMINOUS FLUX, HOWEVER WEAK, BY THE USE OF TWO VACUUM PHOTOCELLS IN SERIES [particularly Boutry-Type Cells requiring only 8 Volts and having Very Low Dark Current].—Fleury. (*Comptes Rendus* [Paris], 5th May 1941, Vol. 212, No. 18, pp. 753–755.)

This arrangement, quite different from the ordinary differential photocell combination, has the anode of one cell connected directly to the photocathode of the other. Using Boutry-type cells (3305 *bis* of 1938) a variation of 1% in a millilumen gave a voltage change of about 1 volt, easily measured within 2% by a Lindemann electrometer.

1862. KNORR - ALBERS MICROPHOTOMETER [for Analysis of Spectrographic Plates or Films: with Scanning Unit & "Speedomax" Recording Unit (Pen-and-Ink)].—Leeds & Northrup Company. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, pp. 38–39.)

1863. DISCUSSION ON "A ROTATING DIFFERENTIAL PHOTOELECTRIC PHOTOMETER FOR PRECISION WORK."—MacGregor - Morris & Stainsby. (*Proc. Phys. Soc.*, 1st Jan. 1942, Vol. 54, Part 1, No. 301, pp. 66–69.) *See* 318 of January.

1864. SPEKKER PHOTOELECTRIC FLUORIMETER [for Chemical & Biochemical Analysis, etc.].—(*Review Scient. Instr.*, Nov. 1941, Vol. 12, No. 11, p. 558.)

1865. A QUARTZ PHOTOELECTRIC SPECTROPHOTOMETER [using RCA Type 919 Phototube and Special RCA C7032 Tube with Great Sensitivity below 625 mμ].—Cary & Beckman. (*Journ. Opt. Soc. Am.*, Nov. 1941, Vol. 31, No. 11, pp. 682–689.)

1866. A RECORDING SPECTROPHOTOMETER AND SPECTROPOLARIMETER [Completely Automatic, Wide Spectral Range].—Brode & Jones. (*Journ. Opt. Soc. Am.*, Dec. 1941, Vol. 31, No. 12, pp. 743–749.)

1867. ON THE MEASUREMENT OF THE ABSORPTION COEFFICIENTS OF GASES IN THE EXTREME ULTRA-VIOLET REGION OF THE SPECTRUM [Comparison of Direct (Photoelectric Photometry) & Indirect (Photographic Blackening) Methods].—Mataré. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 22, 1941, pp. 260–268.)

Particular attention is paid to the details of the direct method, including preliminary tests to obtain a satisfactory photocell/amplifier/meter connection (a particularly sensitive arrangement was with a quadrant electrometer in the anode circuit, Fig. 7: this would be particularly suitable for stellar photometry): and to obtain a cell sufficiently sensitive in the region below 200 mμ (a sodium ultra-violet cell, Pressler type, with a thin layer of calcium tungstate on its front glass wall to serve as a frequency converter, was found to give an improved output). Many literature references are given.

1868. PHOTOELECTRIC SMOKE-METERS [Survey, with Literature & Patent References: Projector & Receiver Design: Prevention of Deposition of Foreign Matter on Windows: Voltage Regulation: Balanced Systems: etc.].—Wey. (*Engineer*, 3rd, 10th, & 17th April 1942, Vol. 173, pp. 283–285, 300–303, & 320–322: to be contd.)

1869. A SELENIUM PHOTOCELL FOR LIGHT MEASUREMENTS.—Putseyko. (*See* 1739.)

1870. A METHOD OF LIGHT MODULATION BASED ON THE USE OF A QUARTZ CRYSTAL AT HIGH VOLTAGES.—Mandelstam & others. (Mentioned in 1755, above.)

1871. TROPICAL CLIMATE AND COMMUNICATION TECHNIQUE.—Schulze. (*See* 1672.)

1872. AN INTEGRATING ALTIMETER [Elaborated Aneroid Barometer automatically integrating the Altitude/Pressure Equation (eliminating Uncertainty of Height/Temperature Assumptions) and giving Record of the Ascent].—Charron. (*Comptes Rendus* [Paris], 19th May 1941, Vol. 212, No. 20, pp. 852–854.)

1873. ELECTRONIC MEASUREMENTS IN AIRCRAFT-ENGINE MANUFACTURE.—Whitmore. (*Proc. I.R.E.*, Nov. 1941, Vol. 29, No. 11, p. 605: summary only.) From the General Motors Corporation.

1874. ELECTRICAL [Capacitance-Change] INDICATOR FOR INTERNAL - COMBUSTION ENGINES.—Hagendoorn & Reynst. (*Zeitschr. V.D.I.*, 10th Jan. 1942, Vol. 86, No. 1/2, p. 22: summary, from *Philips Tech. Rundschau*, Vol. 5, 1940, p. 356 onwards.) The capacitance is only 1.5 μμF, the gap 0.2 mm, the natural frequency of the membrane 25 kc/s.

1875. THE MEASUREMENT OF SMALL CURRENTS AND VOLTAGES, AND SMALL CHANGES IN LENGTH, WITH THE BOLOMETRIC COMPENSATOR.—Merz & Niepel. (*See* 1746.)

1876. THE DYNETRIC BALANCING MACHINE [Outputs from Velocity-Type Pick-Ups, at Each Bearing, fed into Network separating Effects of Unbalance in Each Plane: Angular Position of Unbalance also shown].—Vore. (*Proc. I.R.E.*, Dec. 1941, Vol. 29, No. 12, pp. 666–667: summary only.)

1877. A NEW PRINCIPLE FOR STABLE D.C. AMPLIFICATION [for Process Control & Other Purposes].—Eberhardt & others. (*See* 1633.)

1878. THE APPLICATION OF THE CATHODE-RAY OSCILLOGRAPH TO THE MEASUREMENT OF THE INCLINATION VECTOR [for Remote Indication].—Goncharski. (*See* 1772.)

1879. THE ELECTRICAL CAPACITANCE DIAPHRAGM MANOMETER [for Direct Measurements in Arterial Blood Stream, and Other Purposes: with Crystal-Controlled R.F. Oscillator & Cathode-Ray Tube Indicator/Recorder].—Lilly. (*Review Scient. Instr.*, Jan. 1942, Vol. 13, No. 1, pp. 34–37.)